REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (*Leave blank*)

2. REPORT DATE
11/00/85

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
BIOTA ASSESSMENT, TASK 9, DRAFT FINAL TECHNICAL PLAN

5. FUNDING NUMBERS
DAAK11 84 D0016

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
ENVIRONMENTAL SCIENCE AND ENGINEERING
DENVER, CO

8. PERFORMING ORGANIZATION REPORT NUMBER
86238R06

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
ROCKY MOUNTAIN ARSENAL (CO.). PMRMA
COMMERCE CITY, CO

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED

12b. DISTRIBUTION CODE

13. ABSTRACT (*Maximum 200 words*)

PHASE I OF THE TASK 9 WORK EFFORT WILL IDENTIFY THE FOLLOWING:
1. CONTAMINATION SOURCES
2. CONTAMINANTS OF CONCERN
3. CONTAMINANT PATHWAYS THROUGH MAJOR ECOSYSTEMS
4. IMPORTANT BIOTA SPECIES.

PHASE II WILL CONSIST OF ANY NEEDED STUDIES.
SECTIONS OF THIS PLAN DETAIL INFORMATION ON THE FOLLOWING:
1. PREVIOUS STUDIES
2. SCOPE OF WORK FOR PHASES I AND II
3. CHEMICAL ANALYSIS
4. SAFETY.

TWO SHORT REPORTS ARE INCLUDED AS APPENDICES:
A. HABITAT AS A BASIS FOR ENVIRONMENTAL ASSESSMENT
B. GUILDING APPROACH TO SPECIES SELECTION.

14. SUBJECT TERMS
FLORA, FAUNA, CHEMICAL INVENTORY, SAMPLING, ECOLOGY

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
UNCLASSIFIED

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

86238R06
ORIGINAL

LITIGATION TECHNICAL SUPPORT AND SERVICES

Rocky Mountain Arsenal

Biota Assessment

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Draft Final Technical Plan
November 1985
Contract Number DAAK11-84-D-0016
Task Number 9

PREPARED BY

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

PREPARED FOR

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL

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LIST OF ACRONYMS
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AR	Army Regulation
CDOW	Colorado Division of Wildlife
CFI	Colorado Fuel and Iron Corporation
cm	centimeters
DA PAM	Department of Army Pamphlet
DARCOM	U.S. Army Materiel Development and Readiness Command
DBCP	Dibromochloropropane
DCPD	Dicyclopentadiene
DDT	Dichlorodiphenyltrichloroethane
DIMP	Diisopropylmethylphosphonate
DOJ	U.S. Department of Justice
EPA	Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
ft	feet
gal	gallon
Hyman	Julius Hyman and Company
HEP	Habitat Evaluation Procedures
HSI	Habitat Suitability Index
in	inch
IR/DMS	Installation Restoration Data Management System
OSHA	Occupational Safety and Health Act
PMO	Program Manager's Office
PPLV	Preliminary Pollutant Limit Value

LIST OF ACRONYMS
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QA	Quality Assurance
QC	Quality Control
RIC	Rocky Mountain Arsenal Information Center
RI/FS	Remedial Investigation/Feasibility Studies
RMA	Rocky Mountain Arsenal
Shell	Shell Chemical Company
USAMBRDL	U.S. Army Medical and Bioengineering Research and Development Laboratory
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USFWS	U.S. Fish and Wildlife Service
WWII	World War II

1.0

1.0 INTRODUCTION

1.1 DESCRIPTION OF THE RMA PROBLEM

The Rocky Mountain Arsenal (RMA) occupies over 17,000 acres (27 square miles) northeast of Denver, Colorado. RMA is immediately south of the city of Henderson, Colorado and directly east of Commerce City, Colorado in western Adams County (Figure 1.1-1). The South Platte River flows parallel to the northwest boundary and is less than 2 miles from RMA. RMA was established in 1942 and has been used for the manufacture of chemical and incendiary munitions as well as chemical munitions demilitarization. Industrial chemicals were manufactured at RMA from 1947 to 1982.

During the period from 1943 to 1950, RMA distilled stocks of Levinstein mustard, demilitarized several million rounds of mustard-filled shells, and test-fired 10.7 centimeter (cm) mortar rounds filled with smoke and high explosives. During this period many types of obsolete World War II (WWII) ordnance were destroyed by detonation or burning.

In 1947, portions of RMA were leased to Colorado Fuel and Iron Corporation (CFI) and Julius Hyman and Company (Hyman). CFI manufactured chlorinated benzenes and dichlorodiphenyltrichloroethane (DDT). Hyman produced a variety of pesticides, including insecticides and herbicides. Hyman assumed the CFI lease in 1950. In 1951, Shell Chemical Company (Shell) assumed the Hyman lease. Manufacturing by Shell ceased in 1982, but the Shell lease expires in 1987.

Construction of facilities for the production of GB nerve agent began in 1950 and was completed in 1953. Manufacture of GB was continued until 1957 and GB munitions filling operations continued until late 1969.

Basin A, whose boundary is cocontained within Section 36, was the original disposal area for waters and waste waters resulting from all RMA and industrial operations. Basin A was selected because it was part of a natural depression. In 1952, the impoundment dike was raised 5 feet (ft) to handle additional waste generated by opening of the GB plant. During

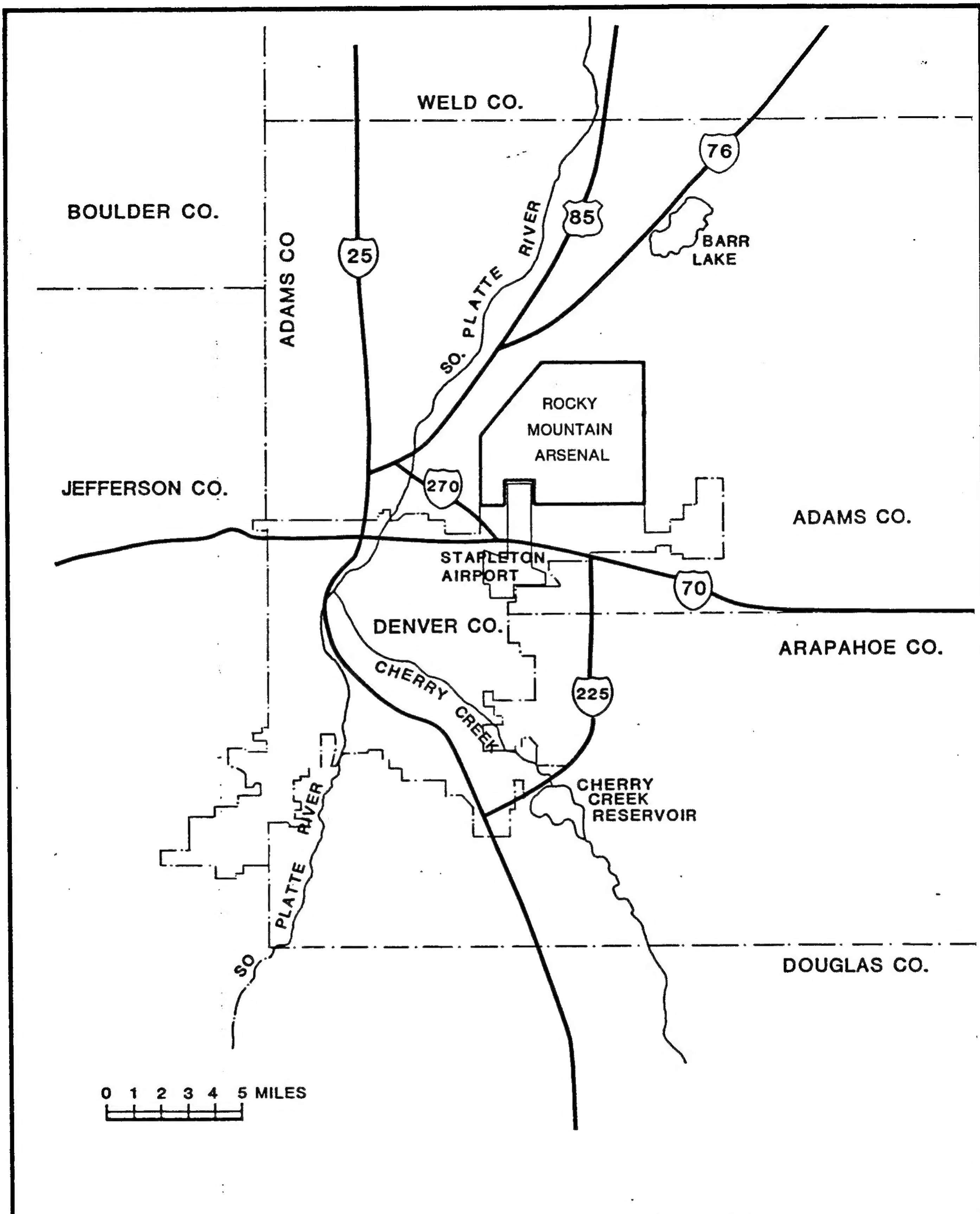


Figure 1.1-1
LOCATION MAP

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

the period from 1943 to 1956, Basin A was the primary receptor of liquid waste. Overflows went through the open drainage to Basins B, C, D, and E, constructed in 1952. Basin F was completed in 1957 to contain all waste waters, and liquids in Basin A were transferred to it by 1958.

During the period from 1965 to 1969 demilitarization of phosgene and cyanogen chloride munitions was performed at RMA. Disposal of mustard munitions occurred from 1972 to 1974, and demilitarization of GB munitions was performed from 1973 to 1976.

Disposal practices at RMA have included routine discharge of industrial waste effluents to unlined evaporation basins and burial of solid wastes at various locations. In general, these disposal practices were poorly documented. In addition to these practices, unintentional spills of raw materials, process intermediates, and final products, have occurred within the manufacturing complexes at RMA. Many of these compounds are mobile in surface and ground waters as well as air.

Deaths and abnormal behavior have been recorded for several waterfowl species in the lower lakes on RMA (Jensen, 1955). Subsequent observation and testing indicated that ducks found dead, dying, or displaying unusual behavior (e.g., flying into buildings) contained high levels of dieldrin and other organochlorine compounds. Since that time, high levels of organochlorines have also been found in fish from the lower lakes, in raptors collected on and near the RMA, and in the flesh of other game animals including ringneck pheasant, mourning dove, and cottontail rabbits.

Chemical analyses of fish and wildlife have been conducted on an annual basis from the early 1970s to the present. These studies have revealed that at least some of the waterfowl, fish, and other fauna from RMA contain levels of pesticides and metals (e.g., mercury) in their flesh which pose a potential health hazard to humans who consume them, and which could adversely affect wildlife by lowering reproductive success, decreasing hatching success of waterfowl, and causing the premature death of young individuals (U.S. Fish and Wildlife Service, 1980A).

In 1954 and 1955 farmers to the northwest of RMA reported severe crop losses due to use of well water for irrigation. In 1974 two contaminants, diisopropylmethylphosphonate (DIMP), which is a by-product of manufacture of GB nerve agent, and dicyclopentadiene (DCPD), a chemical used in insecticide production, were detected in offpost ground water. Since 1974, offpost migration of dibromochloropropane (DBCP), a nematocide which had been shipped from RMA by rail from 1970 to 1975, has been observed in ground water.

Shallow ground water contamination exists in areas north and west of the RMA as a result of onpost activities. Well water in contaminated offpost areas is used to water vegetable crops which are grown for local sale and consumption. Livestock are watered from some of these wells, and are also fed crops raised in the area. Ground water contamination thus poses a potential hazard to livestock and humans as well as wildlife in the offpost area.

1.2 REGIONAL BIOTA

Much of the land on RMA has been disturbed but remains in an undeveloped state. Shortgrass prairie and mixed grasslands predominate over much of the northern portion while lakes, wetlands, and small patches of woodlands are present along the southern section. Development of the area surrounding RMA for residential, commercial, and agricultural use have substantially modified the indigenous vegetation, thus RMA has become a haven for many wildlife species which do not occur in adjacent areas.

1.2.1 ONPOST BIOTA

There are several distinct vegetation types present on RMA which can be classified into three major ecosystem types: grassland, wetland, and aquatic. Most of the land area is grassland, but scattered thickets of small groves of trees are present along waterways and adjacent to buildings. Lakes, sloughs, and small watercourses are located in the southern portion of RMA. Wetlands are present adjacent to the lower lakes and around "the bog" situated along the northern boundary.

Detailed studies have recognized 25 vegetation communities on RMA in addition to areas of bare ground and manmade structures (Santa Barbara Remote Sensing Unit, 1978A). Most of these are grasslands and shrublands which show varying levels of disturbance. Weed species are the dominant vegetation at many locations. Indigenous and introduced plants on and near RMA are mostly common species which are widely distributed throughout the region.

Although native species dominate in some grassland areas, most areas have been disturbed in the past and contain introduced and weed species of grasses and forbs. These areas provide cover, food, and reproductive habitat for animal species such as mule deer, prairie dog, badger, coyote, ringneck pheasant, mourning dove, and a variety of birds of prey such as burrowing owl, red-tailed hawk, and kestrel. Areas of woodland adjacent to wetlands and grassland habitat provide shelter and additional habitat for song birds, game birds, rodents, and deer.

Lakes and ponds, in the southern part of RMA, support populations of game fish including largemouth bass, rainbow trout, bullhead, channel catfish, and bluegills. Fisheries in these lakes are the result of introductions and management (U.S. Fish and Wildlife Service, 1975). Many species of waterfowl and shorebirds inhabit lakes and adjacent wetlands on RMA where they breed, forage, and/or stage in large numbers during periods of migration. Approximately half of the 27 species of ducks documented as inhabiting RMA are known to breed on and near RMA (Colorado Division of Wildlife, 1982B).

1.2.2 OFFPOST BIOTA

The area surrounding RMA is largely ranchland/farmland, rural residential, urban residential, and industrial (Kolmer and Anderson, 1977). Irrigated crops are grown in the area northwest of RMA along the South Platte River. Much of the irrigation water is supplied from the River via a system of canals, but some areas are irrigated with shallow well water. The floodplain of the South Platte River, less than three miles northwest of RMA, contains scattered patches of wetland and mature stands of riparian woodland.

The adjacent land north of RMA consists mostly of rangeland (grassland) and dryland agriculture. Rural residential developments are scattered north and northwest of RMA. Urban developments include Commerce City (west) and Montebello (south). The north runways of Denver's Stapleton International Airport extend into the southwestern corner of RMA.

Cropland and range habitat north and east of RMA provide habitat for game species such as cottontails, ringneck pheasants, and mourning dove. Lake and wetland areas at Barr Lake, five miles to the northeast and downstream from RMA, provide staging, breeding, and resting areas for waterfowl; habitat for edible fish species; and winter habitat for the bald eagle, an endangered species.

1.3 CONTAMINANT SITES AND SOURCES

Numerous potential contaminant sources and contaminant migration sources have been identified on the RMA (Rocky Mountain Arsenal Information Center, 1985). Many of these sites have the potential of adversely affecting plants, wildlife, and humans on and in the vicinity of RMA. Chemical contaminants in the soils, ground water, surface water, and lake sediments provide pathways for these chemicals to enter the biota and adversely affect individuals and populations in the plant and animal communities which comprise the major regional ecosystems.

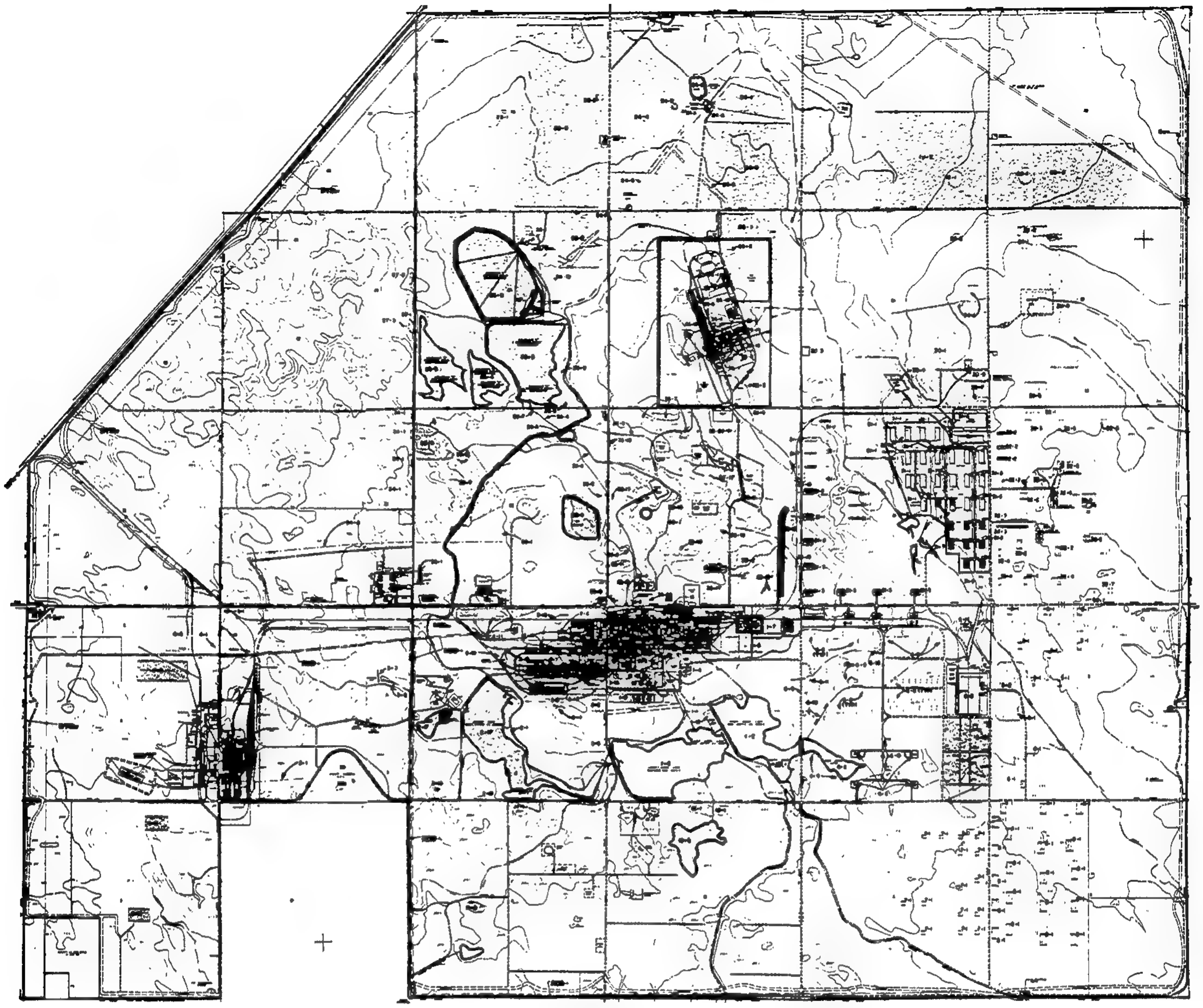
A series of contaminant sources on RMA have been identified as the result of ground water flow studies and chemical analyses of soil and water. Many of the compounds identified as RMA contaminants can become incorporated into the biota, and many (e.g., organochlorine compounds) have known or suspected adverse affects (Thomas _et al._, 1983; Hart, 1976 and 1980; O'Donovan and Woodward, 1977; Palmer _et al._, 1979). The presence of several of these compounds have been documented in plants and wildlife at RMA (Torgeson and Sirois, 1976; U.S. Fish and Wildlife Service 1952; Dugway Proving Ground, 1975A; Cogley _et al._, 1979; U.S. Fish and Wildlife Service, 1965). Some of these compounds have been implicated in wildlife mortalities (U.S. Fish and Wildlife Service, 1952; Dugway Proving Ground, 1975C).

Potential contaminant sites have been identified in 19 of the 28 sections or partial sections of land within the boundaries of RMA (Figure 1.3-1). Sources include a variety of locations and facilities such as chemical and sanitary sewers, unlined disposal pits and lagoons, burn pits, landfills, storage sheds, buildings, bomb disposal areas, chemical spill areas, surface drainage ditches, and lakes.

The major identified sources of contamination on RMA include Basin F (a lined but leaking liquid waste storage lagoon in Section 26), the South Plants area (including buildings, storage tanks, chemical and sanitary sewers, and chemical spill sites), and several discrete sites within Section 36. Basin A, a 120 acre site in Section 36, received wastes and by-products from most industrial processes at RMA and probably contains a broad variety of chemical compounds. Additional contaminant sources such as insecticide pits, lime pits, and burn areas also occur within Section 36.

The Lower Lakes on RMA (Lake Mary, Lake Ladora, Upper and Lower Derby Lakes, and the Rod and Gun Club Pond) located in Sections 1, 2, 6, and 12 in the southern portion of RMA also contain contaminated areas and are potential sources of contamination (USATHAMA, 1983 and 1984). Portions of these lake sediments either have been or still are contaminated with pesticides, primarily aldrin and dieldrin (Colorado State University, 1984; U.S. Army Waterways Experiment Station, 1983).

Ground water studies have determined that additional areas of chemical contamination north and west of the RMA are a result of the offpost migration of contaminated ground water (USATHAMA, 1984). Additional information on the nature, extent, and concentrations of contaminants in ground water offpost is being gathered as part of the Offpost Contamination Assessment Program. Contaminants in shallow aquifers offpost may provide additional exposure pathways to biota by contaminating offpost surface waters or through the direct watering of crops and livestock from wells which draw from shallow contaminated aquifers.



ROCKY MOUNTAIN ARSENAL

EXPLANATION

- Sites Likely to Contain Contaminated Materials
- Contaminated Sites Addressed Under Baseline Actions
- Balance of Areas Investigated

N

0 ½ 1 2 MILES

SCALE

AREAS INVESTGATED AS POTENTIAL CONTAMINATION SITES ON RMA

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

A total of 54 RMA related chemical contaminants are being analyzed in Phase I efforts on other tasks. The biological effects of some of these such as the pesticides aldrin and dieldrin are well known, but exotic compounds related to the production of chemical weapons and rocket fuels are not well understood. Although the array of chemicals expected to be found at some sites is limited (e.g., organochlorine compounds and mercury in lake sediments), other sites have complicated histories of contamination and may contain dozens of different chemical contaminants (e.g., Basins A and F). The biota assessment of chemical contamination at RMA must, therefore, address the concentration, exposure pathways, and biological effects of each of these chemicals for each of the contaminated sites on and near RMA.

1.4 PAST BIOTA STUDIES

A substantial body of information on the presence and distribution of contaminants in RMA biota exists as a result of past investigations conducted since the mid-1950's (Rocky Mountain Arsenal Information Center, 1985). Many of these investigations have documented high levels of several contaminants in plants and in several species of wildlife.

Comprehensive studies of the vegetation included mapping the overall distribution of vegetation types on the RMA (Santa Barbara Remote Sensing Institute, 1978A). Color-infrared aerial photography of the RMA indicated that plant communities within known areas of contamination (e.g., near Basin F) exhibited stress. Some areas supported vegetation consisting of single stands of weedy species or were bare ground. Twenty-five plant community types and six non-vegetated cover classes were differentiated as a result of these studies.

Subsequent vegetation studies were conducted with the objective of monitoring movements of environmental contaminants on RMA (Santa Barbara Remote Sensing Institute, 1978B). Research focused on three areas: 1) plant community studies, 2) remote sensing studies, and 3) literature surveys on the bioconcentration of RMA contaminants which might serve as biological indicators of contaminated areas. The study resulted in a suggested procedure which was apparently never implemented.

Soil samples from the coring program at RMA were tested for the presence of phytotoxic substances (Torgeson and Sirois, 1976; Cogley et al., 1979). The phytotoxicity data did not indicate the presence of phytotoxins except in areas already known to be contaminated on the basis of chemical analyses of the soil samples. Section 36 was extensively contaminated with phytotoxins generally present over approximately 100 acres. Adjacent portions of Section 35 had two sites showing phytotoxic contamination, and evidence of additional phytotoxicity were encountered in Sections 9, 22, 24, and 26. Most toxicants were found in the upper two feet of soil, occasionally in the horizon from 7 to 12 feet, and rarely below 12 feet.

Additional studies have been conducted on some of the chemical contaminants, particularly those which are peculiar to RMA activities, to determine the possible biological effects and concentrations necessary to produce effects (O'Donovan and Woodward, 1977; Guenzi et al., 1979; Palmer et al., 1979; Hart, 1976 and 1980; Thake et al., 1979). Although valuable information has been obtained, comparable types of information (e.g., dose levels, physiological effects, toxicity, mutagenicity, effects on reproduction, ability to produce physical abnormalities, etc.) for many suspected compounds of concern are still unavailable. Numerous studies of contaminant levels in plants, invertebrates, fish, and wildlife have been conducted since the early 1960's (Sheldon and Mohn, 1962: U.S. Fish and Wildlife Service, 1965; Dugway Proving Ground, 1973 and 1975A, B, and C; U.S. Army Environmental Hygiene Agency, 1976; Rocky Mountain Fisheries Consultants, 1977; Thorne, 1982; U.S. Army Waterways Experiment Station, 1983; U.S. Army Rocky Mountain Arsenal, 1984).

Several fish species including northern pike, bass, rainbow trout, bullhead, channel catfish, and bluegill from the lower lakes on RMA were sampled for contaminants. Waterfowl from Basin F and from the lower lakes area were sampled on several occasions to determine levels of contaminants in their flesh. Although several compounds were present in detectable levels, the primary chemicals of concern for both fish and waterfowl were organochlorines associated with pesticide production (Sheldon and Mohn, 1962; Dugway Proving Ground, 1973; Thorne, 1982). At

least a few individuals of all the fish species sampled and all of the waterfowl, including 27 species of ducks found dead or dying on RMA, were found to contain high levels of contaminants, primarily the pesticides aldrin and dieldrin.

Waterfowl losses associated with contaminated sites on RMA ranged from 2,000 to 3,000 individuals annually (U.S. Fish and Wildlife Service, 1960). Although scare devices have been installed at Basin F, waterfowl mortality figures are still about 200 to 250 individuals per year at that location (Thorne, 1983). Dead and dying ducks and ducks exhibiting abnormal behavior as a result of chemical contamination (presumably from RMA sources) have been observed on Upper Derby, Lower Derby, and Ladora Lakes on RMA. Studies by the U.S. Fish and Wildlife Service have shown that resident ducks were the hardest hit by contamination. Ducks were observed to die of convulsions, fly with noticeable loss of equilibrium, and in several instances fly at full speed into the sides of buildings (U.S. Fish and Wildlife Service, 1952). One mallard which died while showing lethal toxic signs at Lower Derby Lake had 1.3 ppm endrin in the brain (U.S. Fish and Wildlife Service, 1982B). This is above the lethal level of 0.7-0.8 ppm for birds (Stickel et al., 1979).

Several additional wildlife species have been tested regularly for chemical contamination. The species sampled include cottontail rabbits, ringneck pheasant, mourning dove, and occasionally mule deer. Control animals are obtained from an area several miles from RMA and are also analyzed for contaminants. Results consistently indicate that higher levels of contaminants are present in the flesh of animals found at selected locations near sites of contamination on RMA than from animals collected from offpost control areas (Thorne, 1982).

The data from other studies conducted at RMA in the past also show high levels of organochlorines in diverse animals including spadefoot toads, great blue heron, starling, and redtail hawk (Dugway Proving Ground, 1973; U.S. Army Environmental Hygiene Agency, 1976; Thorne, 1982). A golden eagle which was shot near the edge of RMA contained 0.15 ppm dieldrin in breast muscle tissue and 1.7 ppm in fat tissue. These levels

are higher than those reported by Reidinger and Crabtree (U.S. Fish and Wildlife Service, 1982B).

Studies have been conducted on kestrels (sparrow hawks) by the Patuxent Wildlife Research Center of the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service, 1982B). Studies indicate that adverse effects on populations of these birds may be related to sites of contamination on the RMA. Chemical analyses are being conducted and data prepared which should elucidate the relationship between these birds and RMA contaminants.

The levels of some contaminants (e.g. dieldrin, mercury) in the flesh of game animals and edible fish at RMA exceeds the Food and Drug Administration (FDA) action levels for animal and fish tissue (Food and Drug Administration, undated). The U.S. Fish and Wildlife Service has expressed concern to the Colorado Department of Health regarding the potential health hazard to humans (U.S. Fish and Wildlife Service, 1981). Concern has also been expressed by the Colorado Division of Wildlife over the movement of pheasants contaminated with pesticide residues off RMA onto private lands on the north and east sides of RMA where they can be hunted. These birds are reportedly contaminated above levels acceptable for human consumption (U.S. Fish and Wildlife Service, 1981).

Crude bioassay tests have been conducted on the aquatic ecosystem of the lower lakes which indicated that tadpole survival in water from Derby Lake was no different than the survival rate in the control; however, algae from Upper Derby Lake was sufficiently toxic to kill tadpoles within two weeks of exposure (Finley, 1959). Other data on bioconcentration of RMA contaminants exists which is consistent with generally known pathways of bioconcentration for organochlorine compounds.

1.5 SUMMARY OF TECHNICAL APPROACH

The biota assessment as described herein will fulfill the general need for comprehensive information on the plants and animals on and near the RMA in relation to chemical contamination. The technical approach is

designed to acquire and summarize existing information and to obtain any necessary additional information on the biota of RMA and the surrounding area. The primary objectives of this biota assessment are:

- to provide technical support to the Department of Justice (DOJ) and their expert consultants for litigation preparation on issues of liability in the environmental resource damage portion of the lawsuit,
- to provide specific information on the migration of contaminants through the local food web, and
- to partially fulfill the U.S. Environmental Protection Agency (EPA) Remedial Investigation/Feasibility Study requirements for hazardous waste sites under the National Contingency Plan.

1.5.1 COMPATIBILITY WITH OTHER RMA MONITORING PROGRAMS

Past investigations of the biota at RMA are discussed in Section 1.4 of this Technical Plan. Current studies by the Program Manager's Office (PMO) staff at RMA of the contamination in the fish and wildlife are scheduled to end prior to the implementation of any biota studies under this task. Close coordination has been initiated and will be maintained with the PMO staff at RMA to avoid duplication of effort and ensure the acquisition of pertinent litigation quality data.

The biota subtask of the Offpost Contamination Assessment Program is directed at determining the potential for movement of contaminants offpost via wildlife species which could pose a health hazard to humans. Work on this subtask presently involves trapping and radiotelemetry studies to determine the home range and seasonal movements of resident wildlife species, specifically cottontail rabbits and the ringneck pheasant. Other potential effects of chemical contamination on the structure, components, and function of regional ecosystems are not considered.

Each of the other environmental tasks being conducted for the U.S. Army at RMA involves some level of contamination assessment for specific sources and/or locations on and in the vicinity of the RMA. This task

assesses the natural resource damage on the biota for each of the locations/sources identified in other environmental tasks. Types of information which will be acquired include qualitative and quantitative information on the potentially affected biota, the effects of chemical contaminants on various components of the ecosystem (including important wildlife species such as game birds and fish), the determination of pathways of contaminant movement into the biota from regional sources (e.g., surface water, soil, etc.) and via the food web for each of the three major ecosystems present in the region, and continued investigation of the potential human health hazard via the biota pathway.

Close coordination and regular communication with other tasks and with the Shell Wildlife Studies team will be maintained in order to incorporate information relevant to the biota assessment and to avoid duplication of effort among concurrent investigations. Data on the distribution and concentration of RMA contaminants in the soils, ground water, and surface water which are being collected under Phase I of other RMA environmental tasks will be reviewed prior to the development of any field studies for the biota assessment.

1.5.2 SCOPE OF WORK

A comprehensive assessment of the flora and fauna on and near the RMA will be conducted in relation to the problem of RMA chemical contamination. The program of investigation will be performed in two phases. Phase I will essentially be a screening activity for the identification of important biotic species, contaminants of concern, contaminant locations/sources of interest, and contaminant pathways through major regional ecosystems. Phase II will focus on filling data gaps and on the acquisition of quantitative information on specific aspects of RMA contamination in relation to regional biota. Components of each phase will be consistent with the general outline for assessing damages to biological resources provided in the draft Natural Resource Damage Assessments document issued by the U.S. Department of the Interior (DOI) (U.S. Department of the Interior, 1985).

Phase I will involve the compilation of existing information on the presence and distribution of RMA contaminants in the biota. A brief field survey will be conducted to document existing conditions and note recent changes in the presence and distribution of plant and animal communities on RMA as part of this preliminary assessment process. Phase I will also involve the development of criteria for determining contaminant loadings on biota, identify data gaps, and subsequently produce a refined scope-of-work for any additional field studies which may be required in Phase II.

The contamination assessment portion of the Phase I studies will involve the development of several different data sets. A comprehensive food web will be constructed for each of the three major regional ecosystems (grasslands, wetlands, and freshwater aquatic) in order to provide a basis for determining potential pathways of movement for contaminants into the regional biota. Key contaminants of concern to biota will be refined on the basis of data acquired from the literature and from other environmental tasks. A list of plants and animals known to inhabit the RMA, including the identification of important species, will be developed. This phase will also include the construction of a human "sink" food web which includes wildlife, fish, domestic crops, and livestock.

Phase II will consist of any field and laboratory studies needed to address the overall objectives of the biota assessment. These studies would be based upon information acquired and evaluated during Phase I. Study design would rely heavily on the definition of contaminant sources and concentrations in soil, surface water, ground water, and man-made facilities obtained as a result of the Phase I portions of other RMA environmental studies. Any such studies would be coordinated with Phase II efforts of other environmental tasks.

Pertinent data on biological pathways, dose levels, and biological effects will be provided to the "How Clean is Clean?" committee. This information will be used to determine what levels of contaminants can remain in the various biotic and abiotic components of ecosystems on and near the RMA and still permit unrestricted use of the area.

2.0

2.0 PHASE I: EVALUATION OF EXISTING INFORMATION

This phase will involve the compilation and evaluation of all pertinent information on biota in relation to RMA contaminants. Although much of this information has been developed in relation to specific contamination problems at the RMA, no single data base exists which includes current and historical information on species presence and abundance, contamination sources/locations, contaminant concentrations and distributions, biological effects, and other data pertinent to a comprehensive biota assessment. Current data on the distribution of vegetation types and recent disturbances are also needed and must be obtained from brief field surveys of the RMA and adjacent offpost areas. This information will be incorporated into a preliminary biota assessment consisting of several parts.

The focus of most studies of contamination in the biota at the RMA was largely to investigate the potential contamination pathways to humans via wildlife (e.g., mourning dove, cottontails, and mule deer) and edible fish (e.g., largemouth bass, catfish, and bullhead). Comprehensive studies on the movement of contaminants through the food webs on and adjacent to RMA and the potential impact on regional ecosytems have not been attempted. Studies of the secondary contamination of offpost biota, including vegetable crops and livestock exposed via contaminated ground water, are also lacking.

2.1 PRELIMINARY ASSESSMENT

The initial activity under Phase I will be a preliminary assessment of existing information from all available sources and a brief field survey of the RMA and vicinity to update information obtained from other sources. This preliminary assessment will result in the compilation of information from diverse sources in order to construct species lists, develop regional food webs, delineate sources/areas of concern, and identify biotic effects of contaminants as called for under the Phase I biota contamination assessment (Section 2.3).

2.1.1 STUDY AREA

For purposes of this assessment, the area defined for investigation includes all of the RMA and the study area for the Offpost Contamination Assessment, including Barr Lake and associated upstream surface waters (Figure 2.1-1). The offpost area has been defined on the basis of the distribution of potentially contaminated ground water, surface waters, and sediments which may provide sources of contamination for plant and animal species offpost. If review of existing information indicates this area should be expanded for investigation in Phase II, the appropriate revision will be incorporated into the draft Phase II Plan at the conclusion of Phase I studies.

2.1.2 REVIEW OF EXISTING INFORMATION

Numerous reports on the presence and concentration of contaminants in selected wildlife and fish species at the RMA have been accumulated since the mid-1950's. Most of these are available from the Rocky Mountain Arsenal Information Center (RIC) at the RMA. Additional studies conducted for the RMA and others which are published in the open literature provide information on the dose levels, biological effects, and pathways of movement for some of the chemical contaminants identified as present on the RMA. Information on the distribution, general population density, habitat affinities, and food habits of animal species is available from regional libraries and agencies. Current information on land uses surrounding the RMA, concentrations and distribution of contaminants in abiotic components of regional ecosystems (from Phase I portions of other environmental tasks), and acceptable methodologies for biota assessments at hazardous waste sites (presently being developed by the DOI for the EPA) are available from diverse sources. The RIC is a repository of materials relating to the RMA which presently contains over 1,400 items including: documents, maps, correspondence, news articles, and photographs relating the installation restoration program at the RMA. There are four card catalogs cross-referenced by title, performing organization, subject category, and study area. Newsletters and listings of all new documents are issued monthly. Relevant reference materials have been obtained from the RIC and will be incorporated into the biota assessment data base.

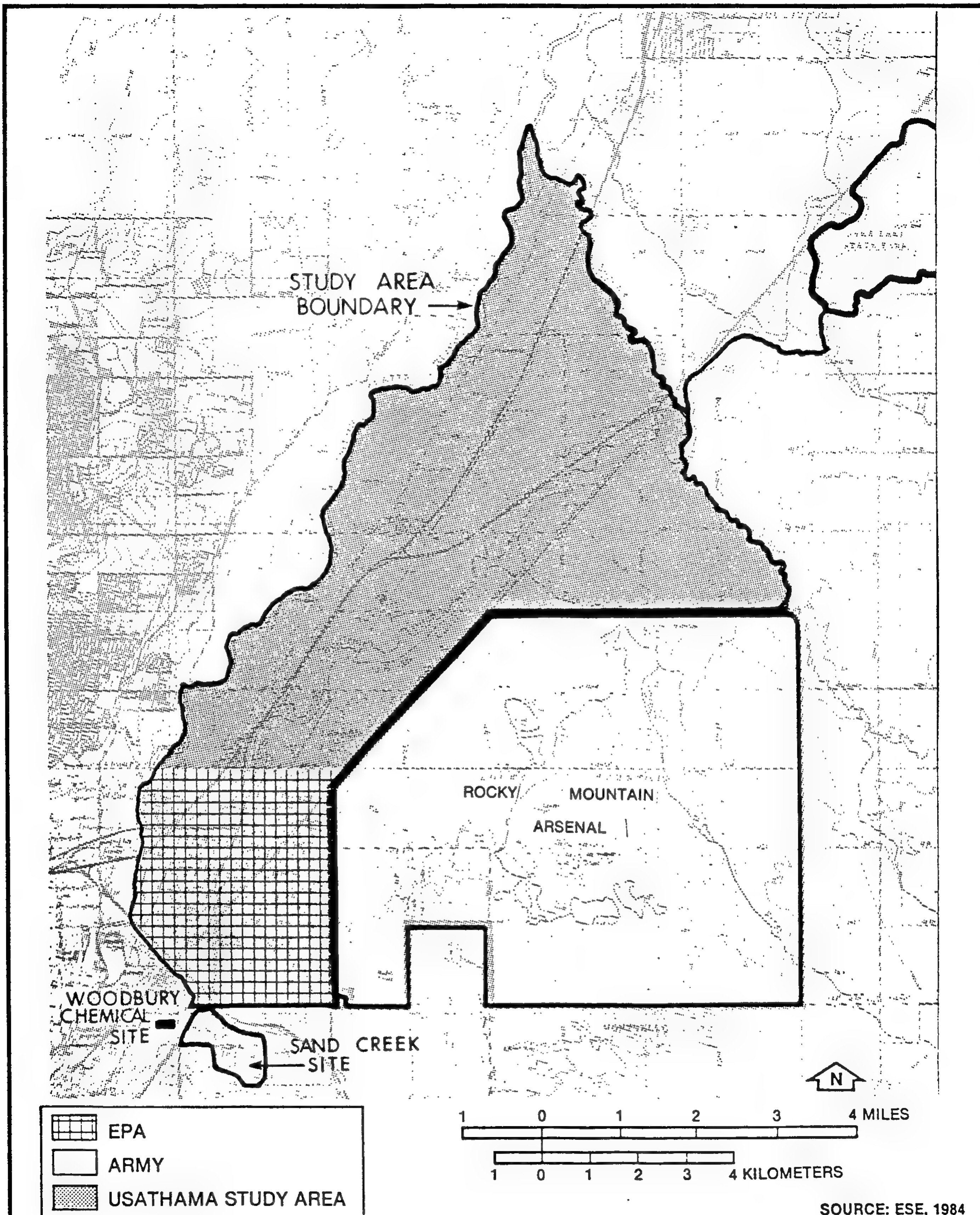


Figure 2.1-1
STUDY AREA BOUNDARIES

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

Over 180,000 documents have been accumulated in the data base for the preparation of interrogatories under Task 3 of this contract. These materials directly concern the RMA and have been examined in relation to the preliminary assessment. Because these information centers and the RIC are continuously being updated, it will be necessary to search each during the initial stages of the preliminary assessment and again just prior to preparation of the Phase I reports. Information from depositions which are currently being taken will become a part of this data base and will also be reviewed.

Several additional sources of information on regional biota will be investigated during the preliminary assessment. The U.S. Fish and Wildlife Service at the Denver Wildlife Research Center contains published information and reports on regional wildlife which will be used in evaluating the trophic status of important species in regional food webs.

A library of materials pertaining specifically to Colorado wildlife and environments is available at the headquarters of the Colorado Division of Wildlife (CDOW) in Denver, Colorado. The CDOW library contains maps showing the current distribution of important wildlife species. A computerized data base contains additional specific regional information used to update the Latilong Series of publications which show the local distribution, habitat use, seasons of occurrence, and general abundance of vertebrate species. The library also houses special reports and annual updates of information pertinent to the biota on and near RMA. The library and supporting computer facilities will be regularly consulted throughout this phase to gather all available information relevant to the biota assessment.

The Patuxent Wildlife Research Center has conducted studies of the effects of pesticides on kestrels (sparrow hawks) on and adjacent to the RMA. The studies are complete, but some reports are still in preparation. Copies of the draft reports should be available within the time frame of this preliminary assessment and should contain information

directly concerning the effect of pesticide contaminants on biota at the RMA.

The Environmental Division at the RMA houses a collection of plant and animal specimens of species found on the RMA. Additional plant materials from studies conducted at the RMA are cataloged into the herbarium of Metropolitan State College in Denver, Colorado. Both of these collections and their respective curators will be consulted during the preliminary survey.

Other libraries which contain information on regional biota are: University of Colorado at Denver, Denver Public Library, University of Colorado at Boulder, and Colorado State University. Thesis and dissertation materials on regional wildlife species, vegetation types, and/or work conducted on the RMA are available only from these sources. These sources will be searched for information pertinent to the RMA biota assessment.

Additional sources of information either on regional biota or the organization of ecosystems may be present in other libraries or agency facilities identified in the course of acquiring information. Information on wildlife, domestic animals, and crops from questionaires currently being circulated to residents in the offpost study area by the Tri-County Health Department will also be incorporated into the data base for biota assessment. If necessary, visits to these libraries will be made during the preliminary assessment phase with prior approval of the PMO.

It will be necessary to maintain periodic contact with the U.S. Army Medical and Bioengineering Research and Development Laboratory (USAMBRDL) and with some expert consultants throughout the course of this assessment to consult on information found and additional information needed, and to obtain assistance on locating specific types of information. Prior verbal and/or written authorization to make these contacts will be obtained from the PMO.

2.1.3 FIELD SURVEY

A brief field survey will be conducted within the study area to obtain pertinent information on the occurrence, distribution, and general population density of key species of plants and animals. The distribution of major vegetative communities will be documented from aerial photography and ground-truthing visits to the area. Incidental observations on habitat disturbance, plant or animal mortalities, and general site conditions will be documented.

For purposes of this initial survey, key species are defined as:

- species which are listed as rare, threatened, or endangered either federally or by the State of Colorado;
- species of economic importance (e.g., game animals, furbearers, pests, etc.) including those species eaten by humans (e.g., ringneck pheasant and cottontails);
- domesticated species eaten by humans (e.g., vegetable crops and livestock); and
- key species in regional food webs which may be directly affected by RMA contaminants or occur along key pathways of contamination movement through regional food webs.

The field survey will be completed prior to mid-November 1985. Although the time allocated for this work will not be extensive, surveys will encompass both the time period when vegetation is still available for easy identification (prefrost) and the fall migration period for waterfowl and other birds.

Limited vegetation inventories will be conducted to note major species composition in each vegetation type. It is anticipated that the detailed information on plant species which is currently being collected on RMA by Morrison-Knudsen for Shell will be made available to ESE through the PMO for incorporation into Phase I Studies.

Field study methods for wildlife species will include driving and walking surveys of each major habitat type within the study area to note the presence of diurnally active species. Limited live trapping using small

Sherman live traps (3 x 3 x 9 inches) and large Tomahawk live traps (9 x 9 x 32 inches) may be used at selected locations to trap small and medium sized mammals not easily detected by other methods. All animals collected will be released uninjured. Documentation of important or unusual species will be made by photographs. All collecting will be conducted under a valid permit from the CDOW issued for these studies. Wildlife species occurrence will also be documented from observations of tracks and other sign (e.g., scat).

The existing information for most bodies of water within the study area suggest that no sampling will be necessary for fish, aquatic invertebrates, or vegetation in these areas. It is anticipated that the data on aquatic species which will be obtained by Morrison-Knudsen for Shell will also be made available for evaluation during Phases I and II.

Limited field visits will be conducted in areas of known or suspected contamination on the RMA. The biota field team members will not enter these areas without having the proper safety training and without wearing the proper safety attire. No area under present environmental investigation will be entered without the prior notification of and approval by the Army or its designated contractor responsible for that area.

2.2 CRITERIA DEVELOPMENT

ESE will develop relevant criteria for the contamination loading of organisms, tissues, organs, etc. for key plant and animal species as defined in Section 2.1.3 of this Technical Plan. The development of these criteria will be accomplished through a review of pertinent literature and in consultation with USAMBRDL and appropriate expert consultants. Standards and methods for criteria which are currently being developed by the U.S. Fish and Wildlife Service (USFWS) will be incorporated as they become available (U.S. Department of Interior, 1985). This information will be used in determining potentially significant contaminant impacts on key plant and animal species, on the structure and function of regional ecosystems, and on humans on and near RMA.

The development of these criteria will be coincidental with the acquisition and review of all available information. Pertinent input from the "How Clean Is Clean?" committee will also be incorporated into the criteria development process. The Preliminary Pollutant Limit Value (PPLV) concept (Dacre et al., 1980; Rosenblatt et al., 1982) will be applied for some animal species, contingent upon the availability of sufficient data. Although this approach has proven satisfactory for human use, its applicability to the biota has not been assessed. Additional field and laboratory study will probably be necessary in Phase II to obtain appropriate data for calculating PPLV's for most species.

Criteria development will incorporate the findings and methodologies currently being created by expert consultants for quantifying the transfer of contaminants between components of the abiotic environment and the biota. Methods for estimating the incorporation rates of contaminants from soil and water to plants, and for predicting the bioconcentration of chemical contaminants into key species of plants and animals are of particular interest.

2.3 CONTAMINATION ASSESSMENT

The assessment of contamination in regional biota constitutes the major portion of Phase I investigations. The principal objectives of the contamination assessment of biota are to provide specific information on the migration of RMA contaminants through the food webs of regional ecosystems and to partially fulfill the EPA Remedial Investigation/ Feasibility Study requirements for hazardous waste sites under the National Contingency Plan. Information obtained through this assessment will provide a basis for determining the extent of injury to the biotic resources on and near the RMA, assessing any damages, and developing methods of mitigating any damages which may have occurred to these resources.

The first phase of the contamination assessment of biota will focus on the accumulation and analysis of pertinent information in three main areas:

- the biological resources on and near the RMA;
- the presence, distribution, and concentration of contaminants in the abiotic environment (e.g., soil, surface water, ground water, and man-made facilities); and
- the effects of contaminants on various components and key species in regional ecosystems.

Information on the biota will be obtained primarily as a result of literature searches and contacts made as part of the Phase I preliminary assessment. Data on the chemical contaminants and their distribution are currently being obtained from other RMA environmental tasks and will be incorporated into the biota contamination assessment as they become available. Information on the effects of contaminants and their migration/concentration in biological systems will be obtained from literature sources, discussions with expert consultants, and contacts with authorities in the USAMBRDL. Effects which need to be addressed include death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, and physical deformations (U.S. Department of Interior, 1985).

The acquisition and analysis of available information will be used to identify any critical data gaps which exist with respect to the three categories mentioned above. A brief field survey will be conducted to verify and update information available from published and unpublished reports, maps, and aerial photography of the area. These data will be used to evaluate current conditions and to establish a basis for any future investigations which may be needed in Phase II.

The information required is diverse, complex, and probably insufficient for a detailed and comprehensive assessment of contamination effects on the structure, function, and components of biotic systems on and near the RMA. The initial phase of the contamination assessment will provide an integrated data base of available information so that the assessment can be conducted and any critical gaps in the data can be identified. The following specific items will be developed in Phase I from this data base.

2.3.1 SPECIES INVENTORY

Species lists of plants and animals known to occur on and in the vicinity of the RMA will be compiled. Lists will identify those species of plants which are dominant in major ecosystems in the study area (e.g., grasslands, wetlands, and freshwater aquatic). A list of vertebrate animals, including native and introduced fish, which inhabit the area will also be developed. Species lists will indicate which species are resident, migratory, and/or breed in the area. Endangered, threatened, and game species (including edible fish species) will be indicated. Common and important invertebrates (e.g., pest species, those which are prey for game species, etc.) will be listed, based on information from regional publications and agencies and from the collections made on the RMA. These lists will be used in constructing food webs for regional ecosystems and for directly evaluating the actual and potential contamination effects.

Key species of plants and animals will ultimately be identified based on the following criteria:

- species listed as federally threatened or endangered,
- species which are important components of regional ecosystems (e.g., are abundant, are important predators or prey for key species),
- species which are economically important (e.g., game species, crop pests),
- species which are important to the structure and function of regional ecosystems,
- species which have been designated as representative of a tropic level or guild by HEP methodology, and
- species which are of a convenient size or otherwise appropriate for laboratory testing.

2.3.2 POPULATION DENSITIES

The general abundance of key species will be obtained from data gathered during the preliminary assessment portion of Phase I. This information will be used to provide a semi-quantitative basis for evaluating pathways

for the movement of contaminants into and among components of the plant and animal communities on and near the RMA, and for estimating the potential health hazard to humans from consuming plants and animals associated with RMA contaminants. Because several years of data would be required to produce reliable average annual population estimates (Odum, 1971), field investigations to supplement available information are not anticipated to be a part of this biota assessment.

2.3.3 FOOD HABIT STUDIES

Available data on the general food habits of key species inhabiting the RMA study area will be obtained from published literature and will provide a semi-quantitative basis for developing pathways of contaminant movement through regional food webs.

2.3.4 FOOD WEBS

Comprehensive food webs will be constructed for each of the three major ecosystems (grasslands, wetlands, and freshwater aquatic) on the RMA. Food web information will be organized in a data base/spread sheet format on the IBM compatible computer system at ESE. Information on species occurrence, abundance, and food habits will be used. This arrangement will facilitate periodic updating as additional information becomes available. Computer storage of this material will permit analyses by individual food web components and/or compartments.

Food webs will be use to determine major pathways of potential contamination movement through the biota. Comprehensive food webs will provide an indication of which species and/or species assemblages (e.g., phytophagous insects) are involved in major pathways of regional ecosystems. Additional analyses can be conducted on individual species or compartments by examining the appropriate subweb of the comprehensive food web. Although quantitative data on the food habits of key animal species and detailed species lists are required for food web analysis, even incomplete data sets can lead to a functional understanding of the biological systems of an area and produce relevant data on the trophic organization of animal communities (Reagan et al., 1983).

The evaluation of food webs in relation to RMA contaminants will be performed on the comprehensive data sets. A "sink" food web can be created from the comprehensive food web data base which shows all pathways leading to a particular key species (Cohen, 1978; Pimm, 1982). The species in this instance is a sink for materials moving upward through this particular subweb.

Contaminant migration can also be evaluated by creating "source" food webs, actually subwebs, which can display all pathways leading from particular contaminant sources. Each source can be evaluated by specified combinations of known or likely combinations of chemical contaminants. Once defined, these pathways can be submitted to detailed investigation using available data or by gathering additional pertinent information as necessary.

Analysis of the human "sink" food web will be developed in conjunction with the creation of other food webs. This web will include evaluation of pathways of contaminant transfer via wildlife (e.g., cottontail rabbits, pheasants, mourning dove, waterfowl), edible fish (e.g., largemouth bass, catfish, rainbow trout, northern pike), domestic crops (e.g., cabbage, melons, squash, etc.) and livestock (cattle, sheep, pigs) which are raised in the study area and consumed locally. This approach will be coordinated with the PPLV approach being developed by the "How Clean is Clean?" committee.

2.3.5 FIELD SURVEY

Information collected during the brief Phase I field survey will be used to augment published information, reports, maps, and aerial photography acquired as part of the preliminary assessment. Any significant differences between current and expected conditions of species and populations in the region in relation to past or present environmental conditions will also be documented.

2.3.6 CHEMICAL INVENTORY

A data base of RMA chemical contaminants will be obtained. Available information on their biological activity and relevant properties will be

developed and used to evaluate their effects on components of regional ecosystems. Information on dose-response levels will be incorporated as available. Current knowledge of existing literature indicates that basic information may be lacking for selected RMA contaminants; however, these contaminants may not be present in significant concentrations and/or in locations which would pose a hazard to regional biota.

2.3.7 PHASE II SAMPLING SCHEME

The sampling scheme for Phase II will encompass biota studies for onpost and offpost areas. Food chains involving both wildlife and humans will be addressed. The scheme will include the description of any necessary field and/or laboratory studies including any required laboratory certification for evaluating contaminants in plant or animal species. Additional information on potential Phase II studies is presented in Section 3.0.

Materials gathered during Phase I studies will be evaluated to determine if available information is sufficient to address all aspects of the Biota Assessment. The comprehensive food web, data on chemical distribution and concentrations in the biotic environment, information on the biological effects of contaminants, and other materials produced during Phase I will be reviewed and used to identify critical data gaps to be addressed in Phase II.

Quantitative information will be required on contaminant levels in key species in relation to particular sources, exposure pathways for chemical contaminants of interest, and population densities of key species. Any additional studies will be predicated on the availability of appropriate data for the RMA and on the need for such information in relation to specific contaminant sources or key species identified in Phase I.

The regulations for conducting biological studies as a basis for natural resource damage assessment are presently being developed and will be formally released in draft form in December 1985 (U.S. Department of Interior, 1985). Documents pertinent to evaluation of wildlife which are being prepared concurrently with the Natural Resource Damage Assessment

draft will be available at the same time. The USFWS's "Field Operations Handbook for Resource Contaminant Assessment-Field Methods and Materials" and "Use of Habitat Evaluation Procedures and Habitat Suitability Index Models for CERCLA Applications" are particularly relevant to the development of Phase II investigations. Methods and guidelines provided in these documents will be incorporated into any Phase II program based on direct consultation with the U.S. Fish and Wildlife Service. Some of the basic requirements which may be incorporated into future studies include use of the Habitat Evaluation Procedures (HEP) concept, Habitat Suitability Index (HSI) models, and economic analyses.

Implementation of the HEP concept is proposed for obtaining required information for natural resource damage assessments (U.S. Department of Interior, 1985). HSI models which may be developed if the HEP concept is adopted will require additional field data in Phase II (U.S. Fish and Wildlife Service, 1980A). Models available and/or developed for key species selected during the initial phase of the HEP process would need specific habitat information from contaminated and control areas. The outline for these studies, including sampling design, will be presented as part of the sampling scheme for Phase II. Additional information on the rationale for use of HEP procedures as a basis for environmental assessment (U.S. Fish and Wildlife Service, 1980B) are provided in Appendix A.

A detailed sampling scheme will be developed which incorporates all of the aforementioned elements, as necessary. Experimental (source) and control areas will be selected, the species and/or areas to be surveyed will be identified, the sampling design specified, and the protocol for laboratory procedures will be clearly indicated.

Final design of the Phase II sampling scheme will rely on data from the Phase I investigations of other environmental sampling tasks in order to determine which contaminants are present in which area and at concentrations which might produce direct or indirect adverse effects on the biota. Data for several key locations of probable concern (e.g., sites in Section 36) will become available by December 1985 in time to

define sites which may require additional biota assessment studies. Areas which are presently thought to be of greatest concern include the sites in Sections 36, Basin F and surrounding areas, the lower lakes, and portions of the South Plants area. Data from other tasks, particularly those involving contaminant surveys in soils, will provide data to verify the absence of chemical contamination in areas on the RMA which may be selected as control areas for Phase II Biota Assessment investigations (e.g., Tasks 14 and 15 studies of Army sites in the peripheral areas of the RMA). Sufficient information from some of these tasks will not be available until the second quarter of 1986. Consequently, some Phase II investigations may be modified accordingly as these data become available.

3.0

3.0 PHASE II: QUANTITATIVE BIOTA STUDIES

Studies to be conducted in this phase are contingent on the need for additional information beyond that which already exists for biota in relation to chemical contamination at the RMA. The evaluation of existing documents, development of criteria, and completion of the various components of the contamination assessment in Phase I will used to determine what, if any, additional studies are necessary. ESE will be prepared to conduct the Phase II Program with the prior approval of the PMO.

3.1 SCOPE-OF-WORK

A scope-of-work for Phase II cannot be defined until all pertinent information has been compiled and evaluated during Phase I. The complex interrelationships among biota elements and between biota and abiotic components of the environment will result in the development of a correspondingly complicated approach. A scope-of-work which incorporates field sampling, laboratory studies, and chemical analyses may be needed during Phase II of the biota assessment. Potential studies which may be necessary include but are not limited to the following activities.

3.1.1 USE OF HABITAT EVALUATION PROCEDURES

Implementation of HEP for selected animal species may be a substantial part of Phase II investigations. HEP methodology is flexible, but generally involves a number of steps, generally divided into three phases: 1) preassessment activities, 2) baseline assessment, and 3) impact (e.g., damage) assessment.

Key species (evaluation species) for HEP are determined during the preassessment phase (Figure 3.1-1). Other preassessment activities include:

- formation of an assessment team, usually involving a number of agency representatives;
- delineation of study area boundaries (in this case, the onpost and offpost study areas plus other areas of potential effect determined during Phase I);

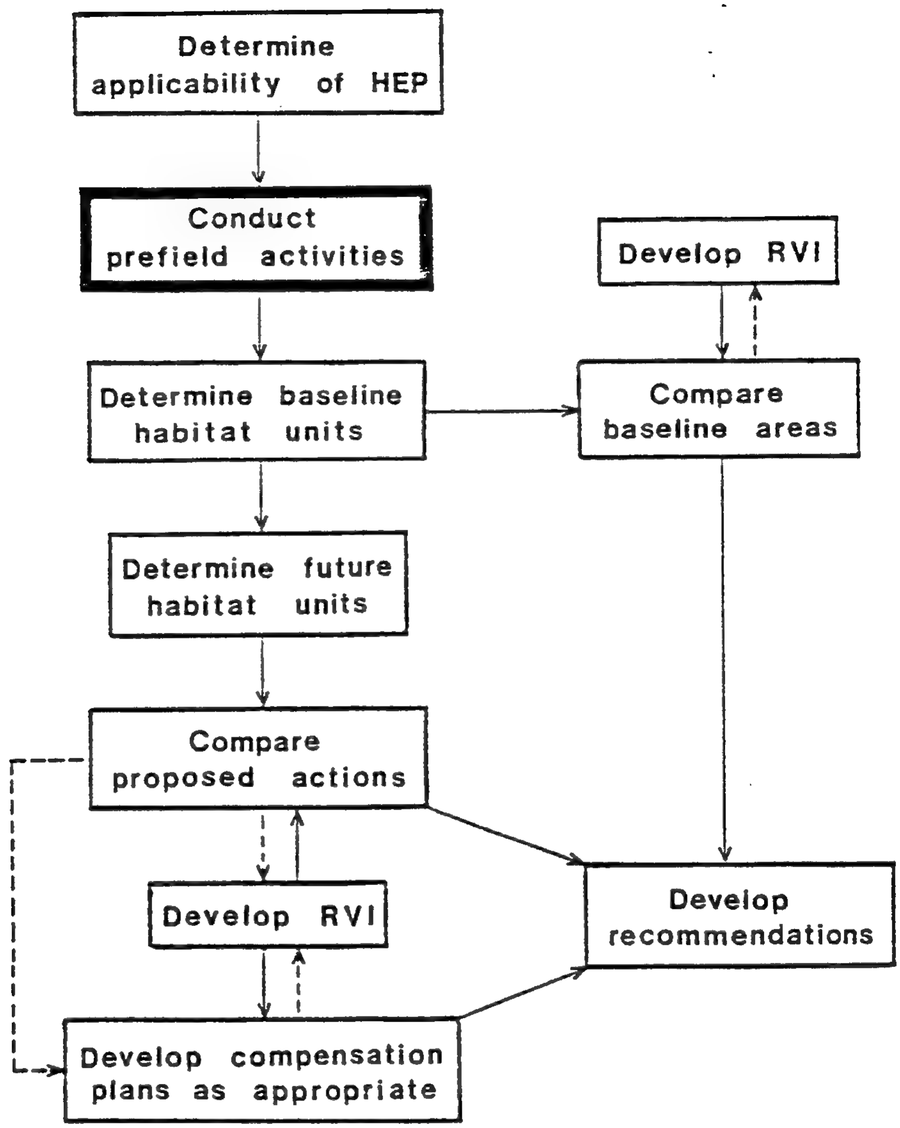


Figure 3.1-1
FLOW DIAGRAM OF HEP PROCESS, EMPHASIZING PREASSESSMENT ACTIVITIES

Prepared for:
U.S. Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland

- o assembly of available data (some additional data to supplement information compiled during Phase I may be required for selected species);
- o delineation of cover types (information obtained from existing aerial photography and updated to current conditions);
- o selection of evaluation species (based largely on data base for selection of key species during Phase I);
- o selection of inventory techniques (based on HSI models existing and/or developed for evaluation species); and
- o final development of sampling design.

The definition of the study area, compilation of most available data, and delineation of cover types will be accomplished during the preliminary assessment portion of the Phase I studies. Some adjustments to each of these may occur as a result of reevaluation by the HEP team. A major element of HEP is the selection of evaluation species. The process recognizes that it is not feasible or necessary to evaluate all species in an area, and incorporates guidelines for the selection of evaluation species. Most elements of this process will be used during the selection of key species in Phase I, but additional species may be selected if HEP is implemented during Phase II. Details of the species selection process for HEP are provided in the HEP Workbook (U.S. Fish and Wildlife Service, 1985) and presented in Appendix B.

3.1.2 FIELD STUDIES

Phase II field studies may include revisions and updating of land use/ cover types on and near the RMA with respect to identified sites of contamination. Maps would be created from existing information, recent aerial photography, and limited ground truthing. These maps would be necessary in evaluation of contaminant pathways and in the selection of experimental and control areas which may be required for field studies of contaminant effects and determination of injury/damages.

Additional field studies of key species, including domestic animals and crops in the offpost study area, may be necessary in order to quantify pathways of contamination movement and effects in regional ecosystems and

to humans via the biota pathways. Studies may include food habits, population densities, and ingestion rates. These studies will be in addition to any field investigations for HEP.

3.1.3 LABORATORY TESTING

Phase I studies may indicate important pathways of contaminants to key species or key compartments of regional ecosystems which have not been previously examined. Information on the effects of these concentrations of some contaminants, particularly those associated with RMA-specific activities may be needed in order to assess the biological effects of these chemicals. Determination of injury may include a variety of effects, not all of which are readily observable in the field. Possible effects include death, disease, behaviorial abnormalities, cancer, genetic mutations, physiologic malfunctions, and physical deformations.

Data on dose levels and effects for many potential contaminants (e.g., organochloride pesticides) is available in the open literature. Some additional data on specific compounds have been produced by the USAMBRDL in relation to RMA contamination. Review of existing information in Phase I will determine what, if any, additional testing may be required in Phase II.

3.1.4 CHEMICAL ANALYSES

Phase I studies for environmental tasks will define the presence, distribution, and concentrations of contaminants for the RMA. Phase I biota assessment studies will acquire information on the dose levels, pathways of movement, and levels of contaminants in selected biota. It is likely that additional chemical analyses will be required for key species identified as a result of Phase I. Additional areas of contamination which may present biological hazards may be identified. Selected species of these areas would need to be analyzed for selected contaminants in order to verify the nature and extent of actual or potential damage as required by proposed regulations (U.S. Department of Interior, 1985).

If these analyses are determined to be necessary, a certification program and sampling program will be instituted. These programs are discussed in Section 4.0.

3.1.5 CONTAMINATION ASSESSMENT

The objectives of this assessment are to evaluate the effects of RMA contaminants on the biota on and near the RMA. All pertinent available information will be used in an initial evaluation, and a determination of the adequacy of this information will be made prior to any Phase II biota assessment studies.

If it is determined that a Phase II Program will be necessary to obtain data for the contamination assessment, the work plan and subsequent technical plan for this program will contain detailed methodology regarding the species involved, locations of experimental and control areas, detailed procedures for collecting field data, and a detailed description of any chemical analyses, required certifications, and rationale for conducting additional studies. Additional data acquired from the Phase II programs of other environmental assessment tasks, particularly those dealing with the distribution and concentration of RMA contaminants in ground water and soils, will be obtained for incorporation into the final Biota Contamination Assessment.

The resulting contamination assessment for biota will provide a comprehensive assessment for ecosystems and key species on and near the RMA. The report will deal with specific sources of contamination on the RMA (e.g., Section 36, Lower Lakes, etc.) and in the offpost area so that the contamination assessment portions of reports for tasks involving these areas can incorporate pertinent biological assessment information. The combined work products from Phase I and II of this biota assessment program will be designed to fulfill the EPA's Remedial Investigations/Feasibility Studies (RI/FS) requirements for a biota assessment and to provide appropriate information on biota for incorporation into the endangerment assessments. The necessary Safety Plan, Data Management Plan, and Chemical Analyses (including

certification) elements applicable to a Phase II program will be included in the draft Phase II program output from Phase I.

Close contact will be maintained with all other ongoing tasks at the RMA throughout the development of the Phase II work plan in order to obtain current information and to avoid potential duplications of effort among tasks. The draft Phase II work plan, developed as a result of Phase I biota assessment studies, will contain specific reference to present and anticipated Phase II work for all pertinent task investigations.

4.0

4.0 CHEMICAL ANALYSIS

The objective of the chemical analysis program is to provide the PMO with reliable, statistically supportable, and legally defensible chemical data regarding the type and level of contamination in selected components of the biota on and near the RMA. During the Phase I studies no chemical analyses will be done; however, historical chemical data on biological samples will be examined to identify possible data gaps with respect to contaminant levels in important species and/or potential important pathways of movement for areas of contamination at the RMA through regional food webs. Chemical analyses of the biota necessary to fill these data gaps will be performed during Phase II.

4.1 CERTIFICATION

Upon determination by ESE that additional chemical analyses of the biota are needed and with the prior approval of the PMO, ESE will conduct a certification program on the tissue matrices of interest. The chemical analyses to be performed and tissues to be analyzed will be determined as a result of Phase I studies. Present information suggests that one or more specific chemical contaminants from the following groups may be involved: pesticides (organochlorine compounds), diisopropylmethylphosphonate (DIMP)/dimethylmethylphosphonate (DMMP), DBCP, and extractable organics. Organosulfur compounds and their metabolites in biological systems and heavy metals may also be included, pending the results of Phase I investigations.

Certification for analysis of biological samples will involve methods development which may require substantial time and effort. Criteria development in Phase I and the identification of key species and data gaps will be given priority in order to determine what methods may need to be developed/certified so that certification can be initiated without unnecessary delay.

Methods for certification will be submitted to the Government under procedures defined in Task 1 (Contract No. DAAK11-84-D-0016). Upon approval of methods, certification will be conducted on those key

contaminants identified in the contamination assessment portion of this task as providing a "fingerprint" of contamination in the tissues and/or organisms to be analyzed.

4.2 SAMPLING PROGRAM

It is anticipated that some level of effort to obtain material for chemical analyses will probably be required for one or more chemical contaminants in one or more biotic species. Prior to sampling, a protocol will be developed for biota which is consistent with quality assurance procedures described in Section 5.0 of this document and in Section 5.0 of the Task 1 Technical Plan (Contract No. DAAK11-84-D-0016). The detailed design of this sampling program will be developed during Phase I.

5.0

5.0 QUALITY ASSURANCE

Quality Assurance (QA) for Task 9 will be consistent with the Field/Laboratory QA Plan developed for Task 1 activities. The plan is project specific and describes procedures for controlling and monitoring sampling and analysis activities as required under Task 9. As designed, the Field/Laboratory QA Plan will ensure the proper production of valid and properly formatted data concerning the precision, accuracy, and sensitivity of each method used for the PMO sampling and analysis efforts. The plan is based on USATHAMA April 1982 QA program requirements and modifications, and complies with ESE policy. The plan is presented in Appendix B of the Task 1 Technical Plan. Specific RMA QA and Quality Control (QC) requirements are detailed in Section 5.0 of the same document.

6.0

6.0 DATA MANAGEMENT PLAN

Data from Task 9 studies will be handled according to the Data Management Plan in Volume I of the Task 1 Technical Plan, Contract Number DAAK11-84-D-0016. As outlined in the plan, field data will be entered into the Compaq personal computer in ESE's Western Regional Office in Denver, Colorado, and transmitted via telephone to the Compaq computer system in ESE's home office in Gainesville, Florida. The field data will then be transferred to the Installation Restoration Data Management System (IR-DMS) as appropriate.

Biota samples for chemical analyses will be processed by the same handling procedures described for Task 1. Sample number assignments, labels, and logsheets will be made in the ESE Gainesville laboratory and sent to the sampling team. Samples shipped to ESE will follow the chain-of-custody procedures described in the Task 1 Technical Plan. Data from lab analyses will be entered into the Prime 750 computer in ESE Gainesville, incorporated with certification and field data, and formatted into files according to the IR-DMS User's Guide. After validation, these files will be sent to the Univac computer system in Aberdeen Proving Ground using the Tektronix or the Compaq computer systems, run through the data checking routine, and elevated to Level 2.

7.0

7.0 SAFETY PROGRAM

The purpose of this section is to summarize the safety, accident, and fire protection standards, and to outline standard operating procedures to ensure the safety of all personnel performing Task 9 activities. Responsibilities, authorities, and reporting procedures for Task 9 are identical to those designed for Task 1 in Section 7.0 of the Task 1 Technical Plan.

The program addresses all of the requirements of DI-A-5239B and fully complies with the requirements of the Occupational Safety and Health Act (OSHA) and U.S. Army Materiel Development and Readiness Command (DARCOM) Regulation 385-100, Army Regulations (AR) 385-10, and Department of the Army Pamphlet (DA PAM) 385-1 for all activities to be conducted. The program also complies with the ESE Analytical Laboratory Safety Plan.

7.1 WASTE CHARACTERISTICS

In the 40 year history of the RMA, many extremely hazardous chemicals were manufactured, stored, or partially destroyed in demilitarization activities. Key compounds include GB nerve agent, H and L blister agents, munitions, organophosphorus pesticides and herbicides, hydrazine, and toxic metals. A comprehensive list of contaminants of concern is given in Table 7.1-1. Detailed information on many of these compounds is given in Agent Fact Sheet, SMCRM Form 357 (RMA, 1984) and Military Chemistry and Chemical Agents, TM 3-215 and AFM 355-7 (Department of Army and Air Force, 1963). Copies of this information will be available at the ESE support trailer at the RMA.

7.2 GENERAL PROCEDURES

Known and potential areas of contamination at or near the RMA are presently being studied under the various contamination assessment tasks being conducted on soils, ground water, and bodies of surface water/sediments in relation to RMA contaminants for the PMO. The

Table 7.1-1. Contaminants of Concern at the RMA (Page 1 of 2)

Organic Contaminants

Ethylbenzene
Benzene
Aldrin
Endrin
Dieldrin
Isodrin
Dibromochloropropane (DBCP)
Malathion
Parathion
Methylisobutylketone (MIBK)
Chlorophenylmethylsulfide (CPM Sulfide)
Chlorophenylmethylsulfoxide (CPM Sulfoxide)
Chlorophenylmethylsulfone (CPM Sulfone)
Dicylcopentadiene (DCPD)
Hexachlorocyclopentadiene (HCCPD)
Chlordane
Azodrin
Supona
Bicycloheptadiene (BCHD)
p,p-DDT
p,p-DDE
Atrazine
Dimethyldisulfide (DMDS)
Vapona

Table 7.1-1. Contaminants of Concern at the RMA (Continued, Page 2 of 2)

Organic Contaminants (Continued)
Chloroform
Diisopropylmethylphosphonate (DIMP)
Dimethylmethylphosphonate (DMMP)
Dithiane
1,4-Oxathiane
1,1-Dichloroethane
1,2-Dichloroethane
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Carbon tetrachloride
Methylene chloride
trans-1,2-dichloroethylene
Toluene
Xylenes (o-, m-, p-)
Chlorobenzene
Tetrachloroethylene
Trichloroethylene
Inorganic Contaminants
Zinc (Zn)
Copper (Cu)
Chromium (Cr)
Cadmium (Cd)
Lead (Pb)
Arsenic (As)
Mercury (Hg)

Source: ESE, 1984

technical plan for each of these tasks contains an approved safety plan for work in these areas.

All and any biota sampling which involves entering these areas of known or suspected contamination will be conducted by ESE personnel who have the appropriate level of safety training for work in these areas. All pertinent safety procedures for work within hot zones will be strictly followed. These areas of known or potential contamination will be entered only after prior permission has been obtained from the safety officers of the sites to be investigated. Work in these areas is not anticipated for the brief field investigation to be conducted in Phase I. It is anticipated that only limited work (e.g., mammal trapping, vegetation sampling, etc.) will be necessary in such areas during the proposed Phase II sampling program.

8.0

8.0 CONTAMINATION ASSESSMENT

The Contamination Assessment will be conducted under the two program phases described in Section 2.0 and 3.0 of this Technical Plan. A Preliminary Assessment will be prepared in Phase I and included as an output of this Phase. If additional studies are necessary in Phase II to fill data gaps, the Preliminary Contamination Assessment will be revised accordingly and produced at the end of Phase II.

BIBLIOGRAPHY

BIBLIOGRAPHY

Burchfiel, J.L., Duffy, F.H., and Simm, V.M. 1975. Persistent Effects of Sarin and Dieldrin Upon the Primate Electroencephalogram. Department of Army, Aberdeen Proving Ground, Maryland.

Cogley, D.R., Craker, L.E., Torgeson, C.D., and Sirois, D.L. 1979. Biological Testing of Rocky Mountain Arsenal for Phytotoxic Substances, Final Report. Wilmington, Massachusetts.

Cohen, J.E. 1978. Food Webs and Niche Space. pp. 189. Princeton University Press, Princeton, New Jersey.

Colorado Division of Wildlife. 1981A. Colorado Divison of Wildlife Internal Correspondence to Jack Grieb from John Seidel. Regarding Pheasant Contamination at Rocky Mountain Arsenal.

Colorado Division of Wildlife. 1981B. Colorado Reptile and Amphibian Distribution Latilong Study. 2nd Edition. Nongame Section, Colorado Division of Wildlife, Denver, Colorado.

Colorado Division of Wildlife. 1982A. Colorado Mammal Distribution Latilong Study. Colorado Division of Wildlife, Denver Colorado.

Colorado Division of Wildlife. 1982B. Colorado Bird Distribution Latilong Study. Colorado Division of Wildlife, Denver, Colorado.

Colorado State University. 1984. Sediment Investigations in Lower Derby and Ladora Lakes. Final Report, April 1984.

Dacre, J.C., Rosenblatt, D.H., and Cogley, D.R. 1980. Preliminary Pollutant Limit Values for Human Health Effects. In: Environmental Science and Technology, 14:778.

Directorate of Installation Restoration. 1976. Methodology for Ecological Monitoring of Pesticides, Heavy Metals, and Other Contaminants at Rocky Mountain Arsenal. Department of the Army. Rocky Mountain Arsenal, Denver, Colorado.

Dost, F.N., Reed, D.J., and Wang, C.H. 1968. Inorganic Fluoride Propellant Oxidizers. Volume II. Effects Upon Microorganisms, Fish, and Plants. Oregon State University, Corvallis, Oregon.

Environmental Protection Service. 1975. Methods for Testing Effects of Chemicals on Birds. Environment, Canada Report EPS 1-EC-75-1.

Finley, R.B. 1959. Investigations of Waterfowl Mortality at the Rocky Mountain Arsenal.

Food and Drug Administration. Undated. Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Food. Washington, D.C.

Guenzi, W.D., Beard, W.E., Bowman, R.A., and Olsen, S.R. 1979. Plant Toxicity and Soil Transformations of Soil Incorporated Sulfur Compounds. Final Report.

Hart, E.R. 1976. Mammalian Toxicological Evaluation of DIMP and DCPD. Final Report.

Hart, E.R. 1980. Mammalian Toxicological Evaluation of DIMP and DCPD (Phase 2). Final Report.

Jensen, W.I. 1955. Waterfowl Mortality, Rocky Mountain Arsenal, Summary Report. Denver, Colorado.

Kolmer, J.R. and Anderson, G.A. 1977. Installation Restoration of Rocky Mountain Arsenal, Part I-Pilot Containment Operations. Final Environmental Impact Statement. DOA, RIC#81295R07.

Maugh, II, T.H. 1984. Tracking Exposure to Toxic Substances. Science 226:1183-1184.

Meder, F.J. 1981. Mammalian Toxicological Evaluation of DIMP and DCPD (Phase 3-IMPA). Final Report. Litton Bionetics, Inc. Kensington, Maryland.

O'Donovan, P.A. and Woodward, J.E. 1977. Investigations of the Environmental Fate and Phytotoxicity of DIMP and DCPD. Final Report.

Odum, E.P. 1971. Fundamentals of Ecology, Third Edition. W.B. Saunders Company, Philadelphia, Pennsylvania.

O'Shea, T. and Ludke, J.L. 1979. Monitoring Fish and Wildlife for Environmental Pollutants, U.S. Fish and Wildlife Services, Washington, D.C.

Pacific Northwest Laboratory. 1984. Characterization of Chemical Waste Contamination and Its Extent Using Bioassays. Battelle Memorial Institute.

Palmer, J.D., Cysewski, S.J., Crookshank, H.R., Steel, E.G., and Ivie, G.W. 1979. Toxicologic Evaluation and Fate of Diisopropylmethylphosphonate (DIMP) in Cattle. USDA. College Station, Texas.

Pimm, S.L. 1982. Food Webs. Chapman and Hall, Landon.

Reagan, D.P., Garrison, R.W., and Waide, R.B. 1983. Preliminary Evaluation of Topic Structure in a Puerto Rican Rain Forest. Proc. Octavo Symposio de los Recursos Naturales, San Juan, Puerto Rico.

Rocky Mountain Arsenal Information Center. 1985. RIC Catalog. D.P. Associates, Rocky Mountain Arsenal Information Center, Commerce City, Colorado.

Rocky Mountain Fisheries Consultants, Inc. 1977. Preliminary Aquatic Survey, Rocky Mountain Arsenal, Commerce City, Colorado. Rocky Mountain Arsenal Information Center, Commerce City, Colorado.

Rocky Mountain Fisheries Consultants, Inc. undated. Primary Productivity Estimates in Lower Derby and Ladora Lakes, Ft. Collins, Colorado.

Rosenblatt, D.H., Dacre, J.C., and Cogley, D.R. 1982. An Environmental Fate Model Leading to Preliminary Pollutant Limit Values for Human Health Effects. In: Environment Risk Analysis for Chemistry. Chapter 15.

Santa Barbara Remote Sensing Unit. 1978A. Vegetation Map of Rocky Mountain Arsenal, Commerce City, Colorado.

Santa Barbara Remote Sensing Unit. 1978B. Monitoring Movement of Environmental Contaminants through Ecological Studies at the Rocky Mountain Arsenal, Commerce City, Colorado. University of California at Santa Barbara, Santa Barbara, California.

Sheldon, M.G., Mohn, M.H. 1962. Evaluation of Local Pesticide-Wildlife Problems in the Western United States.

Stickel, L. et al. 1979. Endrin in Birds: Lethal Residues and Secondary Poisoning. pp. 397-406. In Toxicology and Occupational Medicine, Elsevier, New York.

Thake, D.C., Mays, D., Leber, P., Metcalf, D., and Bavada, L. 1979. Mammalian Toxicological Evaluation of p-Chlorophenylmethylsulfide, p-Chlorophenylmethylsulfoxide, and p-Chlorophenylmethylsulfone. Final Report.

Thomas, J.M. et al. 1983. Field Evaluation of Hazardous Waste Site Bioassessment Protocols. Pacific Northwest Laboratories.

Thorne, D.S. 1982. Contaminants in Fish and Game Animals on Rocky Mountain Arsenal 1977-1982. Rocky Mountain Arsenal Information Center, Commerce City, Colorado.

Thorne, D. 1983. Quarterly Reports on Mortality of Waterfowl on Basin F, January 1981-June 1983.

Thorne, D. S., McBride, J.K., Legros, C.R., Ells, J.O., and Manlove, M.S. 1979. Biological Monitoring of Pesticides, Heavy Metals, and Other Contaminants at Rocky Mountain Arsenal. Department of the Army, Commerce City, Colorado.

Torgeson, C. and Sirois, D.L. 1976. Survey of the Rocky Mountain Arsenal for Phytotoxic Substances.

U.S. Army, Dugway Proving Ground. 1973. Incident Report on the Wildlife Mortalities at Rocky Mountain Arsenal During the Period April 4 through June 14, 1973. Dugway, Utah.

U.S. Army, Dugway Proving Ground. 1974. Preliminary Environmental Survey of Rocky Mountain Arsenal, Denver, Colorado. Interim Report. Dugway, Utah.

U.S. Army, Dugway Proving Ground. 1975A. Interim Report on Pesticide Levels in Fish from Two Industrial Lakes at Rocky Mountain Arsenal. Dugway, Utah.

U.S. Army, Dugway Proving Ground. 1975B. Interim Report on Pesticide Levels in Fish Collected March 20, 1975 from Lake Ladora at Rocky Mountain Arsenal. Dugway, Utah.

U.S. Army, Dugway Proving Ground. 1975C. Second Interim Summary Report at Dugway's Findings on the Causes of Waterfowl Mortalities in and Around Reservoir F at Rocky Mountain Arsenal. Dugway, Utah.

U.S. Army, Dugway Proving Ground. 1977. Baseline Ecological Survey of Selected Small Mammals on Rocky Mountain Arsenal, Denver, Colorado. Dugway, Utah.

U.S. Army, Dugway Proving Ground. 1979. Handbook for Evaluating Ecological Effects of Pollution at DARCOM Installations. Vol. 6. Unexpected Declines in Animal Populations. Dugway, Utah.

U.S. Army Environmental Hygiene Agency. 1973. Small Animal Deaths - Rocky Mountain Arsenal, Denver, Colorado. Special Study No. 99-055-73/74. Aberdeen Proving Ground, Maryland.

U.S. Army Environmental Hygiene Agency. 1976. Entomological Special Study No. 44-123-76. Rocky Mountain Arsenal Bird Kill. Aberdeen Proving Ground, Maryland.

U.S. Army, Rocky Mountain Arsenal. 1984. Chemical Monitoring of Fish and Game Animals on Rocky Mountain Arsenal. Denver, Colorado.

U.S. Army Toxic and Hazardous Materials Agency. 1983. Selection of a Contamination Control Strategy for Rocky Mountain Arsenal. U.S. Army, Aberdeen Proving Ground, Maryland.

U.S. Army Toxic and Hazardous Materials Agency. 1984. Decontamination Assessment for Land and Facilities at Rocky Mountain Arsenal. U.S. Army, Aberdeen Proving Ground, Maryland.

U.S. Army Waterways Experiment Station. 1983. Lake Ladora and Lake Mary Sediment Contamination Survey. Preliminary Screening Report. Vicksburg, Massachusetts.

U.S. Department of Interior. 1985. Natural Resource Damage Assessments. Draft. Washington, D.C.

U.S. Fish and Wildlife Service. 1952. Letter correspondence to Rocky Mountain Arsenal, June 4, 1952. Denver, Colorado.

U.S. Fish and Wildlife Service. 1960. Letter correspondence to Rocky Mountain Arsenal, February 26, 1960.

U. S. Fish and Wildlife Service. 1965. Movement and Accumulation of Aldrin in Lakes at the Rocky Mountain Arsenal, Colorado in Relation to Waterfowl Losses. Denver Wildlife Research Center, Denver, Colorado.

U.S. Fish and Wildlife Service. 1975. Fishery Management Program, Rocky Mountain Arsenal, Aurora, Colorado. Special Project Report. U.S. Department of Interior, Vernal, Utah.

U.S. Fish and Wildlife Service. 1980A. Letter correspondence to Colorado Department of Health. Denver, Colorado.

U.S. Fish and Wildlife Service. 1980B. Letter correspondence to Colorado Department of Health, 1980. Denver, Colorado.

U.S. Fish and Wildlife Service. 1981. Letter correspondence to Colorado Department of Health, December 23, 1981. Fort Collins, Colorado.

U.S. Fish and Wildlife Service. 1982A. Chemical Contaminant Residues and Effects on Kestrels and Other Wildlife of the Colorado Rocky Mountain Arsenal. Progress Report, Part I.

U.S. Fish and Wildlife Service. 1982B. Letter correspondence to Rocky Mountain Arsenal, April 14, 1982. Fort Collins, Colorado.

U.S. Fish and Wildlife Service. 1985. Habitat Evaluation Procedures Workbook. HEP Group. Western Energy Land Use Team, U.S. Fish and Wildlife Service, Fort Collins, Colorado.

Williams, J. 1981. Vegetation Studies at Rocky Mountain Arsenal. Thorne Ecological Institute. Boulder, Colorado.

APPENDICES

APPENDIX A

HABITAT AS A BASIS FOR ENVIRONMENTAL ASSESSMENT

Habitat as a Basis for Environmental Assessment

101 ESM

Division of Ecological Services
U.S. Fish and Wildlife Service
Department of the Interior
Washington, D.C.

Preface

Since 1974, the U.S. Fish and Wildlife Service (USFWS) has been developing a habitat-based evaluation methodology entitled the Habitat Evaluation Procedures for use in impact assessment and project planning. This work has lead to the development of a series of documents published as part of the Ecological Services Manual of the USFWS (USFWS 1980). One of these documents, entitled "Habitat as a Basis for Environmental Assessment" (101 ESM), addresses the rationale for a habitat-based technique and discusses the conceptual approach to habitat assessment.

The Habitat Evaluation Procedures (102 ESM) describes how the concepts of habitat evaluation can be implemented in a standardized procedure for conducting impact assessments.

Another document, "Standards for the Development of Habitat Suitability Index Models for Use with the Habitat Evaluation Procedures" (103 ESM), provides guidance in the development of habitat models. These documents provide the user with a basic tool for habitat evaluations.

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1. Introduction

Natural resource management as we know it today is the result of a long evolutionary process influenced by changing public attitudes and legal mandates. The early history of this country portrayed an attitude of natural resource exploitation, with little regard for damages to the environment or losses to future generations of Americans. Fortunately, these attitudes toward natural resources in general, and to fish and wildlife in particular, have changed (Udall 1963; Trefethen 1975). Legislative actions have resulted from these changes, and in some instances, have been initiators of change (Bean 1978).

The purpose of this document is to describe the concepts behind, and the rationale in support of, a habitat-based impact assessment methodology currently available for use in certain aspects of fish and wildlife resource management. The document does not, however, conclude that habitat is the only basis for environmental assessments. Several assessment methods are discussed and compared to selected criteria in reaching the conclusion that a habitat approach is most appropriate within the current legal and institutional constraints on the USFWS. Other criteria can be used, and other equally valid arguments can be made in support of other approaches for impact assessment. This document does not specifically address non-habitat-based impact assessment methodologies such as the monetary and user-day approaches.

This document presents deductive reasoning in support of a habitat approach to impact assessment. It begins with a discussion of the legal mandates for impact assessments (101 ESM 2), progresses through a description of the ecological basis for impact assessments (101 ESM 3 and 4), and concludes (101 ESM 5) with the identification of an assessment technique which has evolved within the USFWS under the selective pressures of legal mandates and accepted ecological principles.

2. Legal Basis for Environmental Impact Assessments

This chapter identifies and describes the legal mandates for environmental impact assessment by reviewing recent Federal legislation affecting fish and wildlife resources. For a compilation of relevant Federal legislations enacted before those treated in this chapter, the reader is referred to Bean (1977) and Congressional Research Service, Library of Congress (1977).

2.1 The evolution of environmental policy. Convergence of natural resource conservation legislation and regulatory mandates to protect public health and welfare first became apparent in the late 1950's and 1960's. The conservation ethic, developed in the early part of the 20th century, evolved into a more holistic environmental perspective which recognized the interdependence of man and his environment. Environmental quality became an important attribute of the public welfare. Early Federal legislation, known as the Wildlife Coordination Act of 1934, later to become the Fish and Wildlife Coordination Act of 1958 (16 U.S.C. 661, *et seq.*), authorized the assessment of adverse environmental impacts associated with Federal water projects. Public concern for the protection of environmental quality, previously applied principally to Federal construction projects, was given application throughout all Federal agencies by the passage of the National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321, *et seq.*). NEPA is the culmination of national concern in the 1960's for natural resource conservation, and public health and welfare legislation. NEPA set the tenor and policy basis for succeeding Federal and State environmental legislation, and established the Council on Environmental Quality.

2.2 Legal mandates for environmental impact assessments. NEPA is the landmark of environmental legislation and has served as the policy umbrella and mandate for numerous other Federal legislation. NEPA sets forth as its purposes: "To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation...." In passing NEPA, Congress recognized the dependence and inseparability of the public health and welfare of the Nation and environmental quality. NEPA applies to all the activities and programs of all Federal agencies. Furthermore, it requires all agencies to consider environmental values along with economic or developmental considerations. Regarding assessment activities, NEPA further stated that all Federal agencies shall:

> "utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decisionmaking which may have an impact on man's environment," and

2.3 Variability in focus of environmental impact assessments. A common feature of all of the laws listed above is the necessity to inventory and quantify the status of air, water, land, and other ecological resources in order to assess, predict, or regulate resource changes resulting from various types of man-induced impacts. A comprehensive definition of environmental impact assessment has been suggested by the International Council of Scientific Unions (1975) as: "an activity designed to identify and predict the impact on man's health and well-being, of legislative proposals, policies, programs, projects, and operational procedures, and to interpret and communicate information about the impacts."

Unfortunately, many differences exist in the focus, scope, and resolution of environmental impact assessments. This stems largely from ambiguous and occasionally contradictory language of various Federal Acts and the lack of concensus among scientists working in this field. The problem is particularly pronounced in assessments dealing with ecological or wildlife impacts. This has contributed significantly to the variability of information gathered by agencies charged by statute with conducting impact assessments.

Congressional requirements to assess impacts on fish and wildlife resources are generally framed around four indicators of public interest: species-populations, biological integrity, environmental values, and habitat. The four indicators are identified in the language of some key environmental legislation. References to wildlife resources in legislative acts are often intentionally vague to allow for more definitive clarification in the regulations drafted by the implementing agency. Frequently, wildlife resources are not mentioned specifically, but are lumped under the general term "environmental resource values."

A. Species-population. The concept that fish and wildlife species or populations or other descriptors thereof can be the basis for determining and assessing impacts is most clearly illustrated in the language of the Clean Water Act. Section 304(a)(1)(A) "Information and Guidelines" states that criteria for water quality should include "extent of all identifiable effects on health and welfare including ...plankton, fish, shellfish, wildlife, plant life..." Section 316(a) requires applicants for a variance from thermal discharge guidelines to "assure the protection and propagation of a balanced, indigenous population of fish, shellfish, and wildlife...." This language reflects the interim goal of the Act under Section 101(a)(2) of achieving water quality "which provides for the protection and propagation of fish, shellfish, and wildlife...." Several other Acts could be interpreted as requiring a species-population approach, notably the Endangered Species Act, the Federal Nonnuclear Energy Research and Development Act, and the Surface Mining Control and Reclamation Act.

2) The environmental impact assessment should objectively predict the quantitative and qualitative short and long term changes in physical, chemical, and biological features associated with alternative ways of achieving the proposed objective. The "goodness" or "badness" of each alternative is determined by the decisionmaker(s) and is not made a part of the assessment.

None of the environmental laws or regulations which require impact assessment prescribe a methodology to be used in the collection, compilation, analysis, or evaluation of natural resource information. The focus of subsequent chapters will be to describe the concepts behind, and the rationale in support of, a habitat-based impact assessment methodology currently available for use in certain aspects of fish and wildlife resource management.

> "identify and develop methods and procedures, in consultation with the Council on Environmental Quality..., which will insure that presently unquantified environmental amenities and values may be given appropriate consideration in decisionmaking along with economic and technical considerations."

Some of the more prominent legislative acts which mandate Federal agencies to environmental conservation include:

A. Archeological and Historic Preservation Act, 16 U.S.C. 469, _et seq_.
B. Clear Air Act, as amended, 42 U.S.C. 7401, _et seq_.
C. Clear Water Act (Federal Water Pollution Control Act), 33 U.S.C. 1251, _et seq_.
D. Coastal Zone Management Act, 16 U.S.C. 1451, _et seq_.
E. Endangered Species Act, 16 U.S.C. 1531, _et seq_.
F. Estuary Protection Act, 16 U.S.C. 1221, _et seq_.
G. Federal Land Policy and Management Act, 43 U.S.C. 1701, _et seq_.
H. Federal Nonnuclear Energy Research and Development Act, 42 U.S.C. 5901 _et seq_.
I. Federal Water Project Recreation Act, 16 U.S.C. 460-1(12), _et seq_.
J. Fish and Wildlife Coordination Act, 16 U.S.C. 661, _et seq_.
K. Forest and Rangeland Renewable Resources Planning Act, 16 U.S.C. 1601, _et seq_.
L. Land and Water Conservation Fund Act, 16 U.S.C. 4601 - 4601-11, _et seq_.
M. Marine Protection, Research and Sanctuary Act, 33 U.S.C. 1401, _et seq_.
N. National Environmental Policy Act, 42 U.S.C. 4321, _et seq_.
O. National Historic Preservation Act, 16 U.S.C. 470a, _et seq_.
P. National Forest Management Act, 16 U.S.C. 472, _et seq_.
Q. Rivers and Harbors Act, 33 U.S.C. 403, _et seq_.
R. Soil and Water Resources Conservation Act, 16 U.S.C. 2001, _et seq_.
S. Surface Mining Control and Reclamation Act, 30 U.S.C. 1201, _et seq_.
T. Water Resources Planning Act, 42 U.S.C. 1962, _et seq_.
U. Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, _et seq_.
V. Wild and Scenic Rivers Act, 16 U.S.C. 1271, _et seq_.

These Acts address the protection, inventory, conservation, or rehabilitation of the environmental resources of the Nation. Many of the above statutes represent organic legislation of Federal agencies such as the Water Resources Council, the Bureau of Land Management, and the Office of Surface Mining Reclamation and Enforcement.

B. Biological integrity. Interestingly, the Clean Water Act also is associated with the biological or ecological integrity approach which attempts to evaluate impacts from an integrated ecosystem viewpoint. The goal of that Act [Section 101(a)] states "The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The ecological basis of this concept is further reflected in Section 304(a)(1)(C) which calls for water quality criteria based "on the effects of pollutants on biological community diversity, productivity, stability..." The Council on Environmental Quality regulations implementing NEPA defines the "effects" which are to be addressed in impact assessments (43 C.F.R. 1508.8): "Effects include ecological (such as effects on natural resources and on the components, structure, and functioning of affected ecosystems)...."

C. Environmental values. The equal consideration of environmental values and economic values to be derived or foregone from a given project or development activity is the essence of the "equal dignity" concept mandated by NEPA. The equal consideration or "values" approach to environmental impact assessment is best illustrated by the Water Resources Council's Principles and Standards (P&S) (38 F.R. 24778, 44 F.R. Part X, and 18 C.F.R. 713). The P&S establish procedures designed to measure and quantify the beneficial and adverse effect of water and land developments on two objectives: national economic development and environmental quality. P&S Section II (B) indicates that: "Beneficial and adverse effects are measured in monetary or nonmonetary terms." P&S establishes the approach to impact assessment based on estimating the monetary and nonmonetary "value" of the components of environmental quality. For example, such things as "biological resources," "ecological systems," "natural beauty," "historical resources," and "water and air quality," are to be compared with economic development factors such as power generation, employment, and flood control. Although philosophically admirable, the implementation of the values approach has been hampered by the difficulty of placing values on intangible and intrinsic environmental components which have unknown or nondeterminable market value.

D. Habitat. The fourth approach to environmental impact assessment is habitat analysis. The Federal Land Policy and Management Act declared that the policy of Congress with regard to the management of public lands under Section 102(a)(8) includes the provision of "food and habitat for fish and wildlife and domestic animals." Section 201(a) of the Act requires "an inventory of all public lands and their resource and other values... giving priority to areas of critical environmental concern." Areas of "critical environmental concern" are defined in Section 103 to include "important fish and wildlife resources."

The Fish and Wildlife Coordination Act requires the USFWS, in cooperation with State fish and wildlife agencies, to conduct surveys and investigations for the conservation of fish and wildlife resources. This Act pertains to Federal construction projects or federally-permitted or licensed projects affecting any stream or other body of water. The Act does not specify any particular assessment methodology. However, the USFWS's draft regulations (F.R. Vol. 44. No. 98. May 18, 1979) implementing this Act recognize the concept and specify the use of habitat values.

The Forest and Rangeland Renewable Resources Planning Act also directs the Department of Agriculture to conduct renewable resource assessments. "The evaluation shall assess the balance between economic factors and environmental quality factors. Program benefits shall include, but not be limited to, environmental quality factors, such as esthetic, public access, wildlife habitat, recreational ..." (16 U.S.C. 1606(d)). Similarly, the Soil and Water Resources Conservation Act calls for "appraisals" including, under Section 5(a)(1), "data on quality and quantity of soil, water, and related resources including fish and wildlife habitats."

The Endangered Species Act also recognizes the importance of habitat to the protection, preservation, and restoration of endangered and threatened species. Section 3(5)(A) defines the term "critical habitat" and Section 4(a)(1) empowers the Secretary of the Interior to "specify any habitat of such species which is then considered to be critical habitat." Section 7(a)(2) requires each Federal agency to ensure that its activities do not "result in the destruction or adverse modification of habitat of such species...." Section 7(b) and 7(c) provide for "biological assessments" and "biological opinions" to make such determinations.

Recent rules and regulations pursuant to the Surface Mining Control and Reclamation Act require the assessment of impacts to fish and wildlife resources. Section 779.20(a) of the Office of Surface Mining Reclamation and Enforcement (OSM) Regulations in 30 C.F.R. requires mining permit applicants to include "a study of fish and wildlife and their habitats." Introductory material to Section 779.20 (March 13, 1979 Federal Register publication, 44 F.R. 15037) of the OSM regulations indicates that the agency's interpretation of Section 515(b)(24) ("minimize disturbance and adverse impacts of the operation on fish, wildlife, and related environmental values..."), is that it includes habitat.

2.4 <u>Variability in scope and resolution of environmental impact assessments.</u> A fairly broad spectrum exists in Federal laws and policies with regard to the resolution and geographic scope of assessments, ranging from broad-based national assessments to site-specific plans. For example,

Federal agencies' legislation addressing impact assessment as part of a regulatory or consultation function tend to require a high degree of resolution and site specificity (e.g., a mining site plan, a stream reach, a construction project site, a timber sale, or a grazing management unit). The Surface Mining Control and Reclamation Act and the Clean Water Act exemplify this category of resolution.

A second category involves legislation calling for basinwide or regional planning assessments with an associated lower degree of resolution. Examples of this type of assessment would include Water Resources Council 13A assessments, Federal Nonnuclear Energy Research and Development Act, P&S level A and B studies, and most NEPA Environmental Impact Statements (EIS's).

The third category or level of resolution includes impact assessments on a national or major geographic basis such as programmatic EIS's, national assessments, and inventories designed to tabulate the natural resources of "all public lands" or "all National forest and rangelands".

2.5 Elements common to all environmental impact assessments. The foregoing discussion pointed out that the legal mandates for environmental impact assessments vary in approach, scope, and resolution. However, at least two common points are recognized:

1) Interactions between physical, chemical, and biological components dictate environmental quality. Thus, to varying degrees, an ecosystem approach to impact assessments is defined.

2) Man has the capability of exploiting natural resources to a point at which his life support system may begin to break down. The legislation subsequent to NEPA provides recognition and reaffirmation of the NEPA goals that modern industrialized society must provide in law for the maintenance, conservation, or rehabilitation of the basic life support system, both for existing and for future generations.

Therefore it follows that certain elements should be common to all potential environmental impact assessment methods. These are:

1) The environmental impact assessment methodology should have the capability to quantify the extent and status of various natural resource components and their susceptibility to irreparable damage or loss. All chemical, physical, biological, economic, and social parameters that are relevant to the change expected to result from a proposed action, should be addressed.

3. Ecological Basis for Environmental Impact Assessments

The preceding chapter explored the legal basis for impact assessments and concluded that there are no clearly defined legal directives for the use of particular methodologies. The purpose of this chapter is to review the ecological basis for environmental impact assessments, and then to explore the general utility of various approaches that might be used to assess impacts on fish and wildlife resources.

3.1 The ecosystem as an organizational unit. Environment has been defined as "the sum total of all physical and biological factors impinging upon a particular organismic unit" (Pianka 1974:2). The "organismic unit" of interest may be an individual, a population of individuals, or a community of populations. The task of assessing impacts on the environment involves: (1) identifying the biological unit whose environment is to be assessed; (2) identifying the factors impinging upon the defined unit(s); and (3) determining how the proposed action will impact the defined unit(s) through alteration of the physical and biological factors impinging on it.

This three step approach which treats factors affecting individuals, populations, and communities is founded on the organizational concept of an ecosystem. An ecosystem approach to environmental assessment may be both natural and artificial. Treating organisms and their environments as functional units is a natural means of organizing efforts in impact assessment. However, artificiality may enter the process when attempts are made to operationally define ecosystems or to delineate actual ecosystem boundaries. Ecosystems can be of any physical size if they are defined by functional attributes (McNaughton and Wolf 1973). However, it should be recognized that setting spatial limits becomes arbitrary because ecosystems represent a continuance in time and space both operationally and conceptually (Johnson 1977).

Unfortunately, ecosystems are seldom treated as a functional continuant during impact assessment; instead the responsibilities and interests of most resource agencies lie with particular ecosystem components. For example, the U.S. Fish and Wildlife Service is specifically charged with the protection of fish and wildlife resources. Fish and wildlife resources are dependent on, and functionally related to, other ecosystem components. In this example, the ecosystem approach is valid as long as the interactions between fish and wildlife and other ecosystem components are defined and considered during an impact assessment. In many instances this integration does not occur and the impact assessment is nothing more than a brief summary of information.

3.2 Methods for assessing fish and wildlife components of ecosystems. Impact assessment requires documentation of the quantity and quality of existing resources, and prediction of how these resources will change in the

future both naturally, and as a result of man's actions. The choice of an assessment methodology should be governed by how well the technique meets certain criteria related to application and implementation of the assessment process. Some potential criteria include:

(1) The assessment method should document and display data in a manner which allows decisionmakers to compare present conditions with future options and alternatives.

(2) The assessment method should have predictive capabilities amenable to documenting changes in quantity and quality of fish and wildlife resources over time. It is not enough to document existing resources; the assessment method must be able to project changes in the resource base which would occur naturally or as a result of implementation of a proposed action by man.

(3) The assessment method must be practical to implement. Data availability, time, and monetary constraints must be considered in the practical application of any method.

(4) The assessment method must be sensitive enough to identify differing types and magnitudes of impacts ranging from enhancement, to no impact, some loss, or to total loss of the resource.

(5) The assessment method should generate data with biological validity, but in units readily understood by both the public and decisionmakers. These data should be amenable to integration with data from other disciplines, such as socioeconomic analyses.

(6) The assessment method should be complete and self-contained yet capable of being improved through the incorporation of new knowledge and techniques as the state-of-the-knowledge advances.

There are probably other criteria which would be applicable, but those presented represent the minimum which should be considered when selecting an assessment method. The following discussion addresses some potential assessment methods in light of how they either meet or fail to meet these criteria.

A. <u>Assessment through analysis of energy flow</u>. One of the most fundamental approaches to evaluation of ecosystems is through analysis of how energy flows through the system and how it is used by various components. Almost any proposed action by man can be summarized as impacting the ecosystem by alteration of energy flow through the system. An energy flow approach has been used as an effective analytic tool in various small and physically well defined systems

(Kormondy 1969; Odum 1971). Some inland aquatic ecosystems lend themselves to this approach (Odum 1957). Each trophic level, from primary producers such as plankton through various levels of consumers, exhibit fairly efficient and measurable energy transfers. However, available energy entering the system does not necessarily determine production of a given species or even a trophic level in terrestrial systems (Wagner 1969). A great deal of energy (nutrient pool) is "locked up" in inaccessible or inedible plant parts and therefore is unavailable to other ecosystem components for extended periods. Energy flow in ecosystems is perhaps more difficult to measure in practice than are aspects of the nutrients involved in its transfer. Biochemical cycle parameters such as transfer rates and pool size are costly to measure, and the interpretation of these data in an impact assessment context is difficult (Johnson 1977).

Systems analysis, systems simulation, and other promising tools have improved the ecologist's capabilities to measure and analyze energy flow in large systems on an experimental basis, but the resulting large scale models still only infrequently produce reliable predictions (Odum 1977). The use of such models also often requires data that are costly and time consuming to collect, and sometimes impractical to measure for each assessment activity.

B. Assessment through population estimation. Of practical value to the resource manager are methods of assessment which not only provide measures of impacts, but which also provide information on population size and production of species of public concern. Many EIS readers are concerned with how many animals will be lost due to the proposed action (Giles 1974). Therefore, methods which document future changes in supply of fish and wildlife resources available for both consumptive and nonconsumptive uses by man should be considered in the assessment process.

The ultimate quantification of changes in numbers of individuals (supply) would be derived from analyses of how various chemical, physical and biological parameters of the ecosystem interact to influence the energy balance of individual animals and, thus their probability of survival and contribution to future populations. However, for the fish and wildlife manager, often the only practical approach to assessment involves either direct or indirect methods of population estimation.

(1) Population estimation - direct approach. Direct population estimation usually involves some type of census which, by definition, implies a complete count of individuals within a

specific area (Overton and Davis 1969); however, virtually all real world situations must rely on estimation techniques. Direct estimation techniques are applicable to populations of individuals which are relatively sedentary (e.g., territorial males of many passerine species), or are concentrated on limited areas (e.g., wintering waterfowl or fish migrating through a fish ladder). However, many species do not lend themselves to accurate, direct population estimation because of mobility, secretive behavior, or habitat characteristics which make observation or counts difficult. Indirect estimation techniques must be used for these types of populations (Watt 1968).

(2) Population estimation - indirect approach. Most indirect methods of population estimation involve the use of indices. Two types of indices are commonly used to indirectly estimate population size. The first type involves a count (e.g., time-area count) taken in a manner which does not permit population estimation unless sampling probabilities are estimated. The second type of index is based on counts of some parameter (e.g., pellet group counts) associated with the species of interest. The strengths and weaknesses of both techniques have been discussed by Overton and Davis (1969).

Estimation of animal numbers at any one point in time is difficult whether direct or indirect methods are used. Several methods should be used (Watt 1968) to ensure accuracy, but this increases the costs of obtaining estimates. Most uses of population size estimates also include a spatial dimension (e.g., density = number of animals per unit area) which requires an estimate of the space utilized by the population under consideration (Krebs 1972).

Even the simplest population estimation model requires data from both the breeding population and their offspring for several consecutive years. Correlative models which reflect past population history are of limited predictive value (Watt 1968). Mechanistic models based on a biological understanding of the species are technically attractive, but the amount of data required to produce such a documented, predictive model is prohibitive for most ecological assessment purposes (Krebs 1972).

Population estimates alone are considered by many to be unreliable indicators of habitat value. Sampling errors, cyclic fluctuations of populations, and the lack of time series

data, all contribute to the problem. Thus, where changes in supply of selected fish and wildlife populations may be a quantity to which decisionmakers and the public easily relate, estimates of changes in numbers of individuals may be difficult and costly to obtain, and too time consuming to use for many impact assessments.

C. Assessment through habitat quality. Habitat has been defined to incorporate several interrelated concepts dealing with space, time, and function (Coulombe 1977). Basically, however, habitat is the place occupied by a specific population within a community of populations (Smith 1974), and often can be characterized by a dominant plant form or some physical characteristic (Ricklefs 1973). Each species requires a particular habitat to supply the space, food, cover, and other requirements for survival. Thus, species are the products of their habitats.

Much of the variability observed in numbers of species and numbers of individuals within populations results from differences in availability of food, cover, water, and other requirements, and in the structural characteristics of the habitat itself (Black and Thomas 1978). Different qualities of habitats produce different densities of various populations. Attempts to quantify habitat quality often involve the use of indices, applied at the individual, population, or community levels.

Some of the most frequently used types of indices are the so-called "condition indices" which involve measurements of some particular characteristic of an animal (e.g., bone marrow fat) to subsequently evaluate the condition of both the animal and its habitat (Giles 1978). Condition indices, like some forms of population indices, are most useful when taken over many years and then compared to some standard to obtain trend information. Such indices are of limited utility for prediction of impacts resulting from specific proposed actions which would alter factors interacting to yield the original index.

Various forms of diversity indices often are used to characterize habitats in an attempt to obtain some measure of quality (Asherin et al. 1979). One of the most common is the bird species diversity index used by avian ecologists. Such indices account for both numbers of species and numbers of individuals of each species present in a particular habitat (Balda 1975). However, diversity indices are insensitive to which species are present (Wiens 1978), often require detailed and expensive measurements which preclude their practical application by resource managers (Thomas et al. 1978), and

suffer from the same problems as all biological indices, namely, identification of the standard of comparison (Inhaber 1976). The methods of determination and ecological relevance of the diversity index has been seriously questioned (Hurlbert 1971); the plasticity of species and species groups in ecosystem structure makes the interpretation of diversity index data difficult (Johnson 1977).

3.3 A unifying approach. Each of the potential approaches to impact assessment described above (energy flow, populations estimation, and habitat quality) differ in their ability to meet previously identified criteria (101 ESM 3.2). Analysis of energy flow may be the most scientifically sound method, but is not practical at present because of time and monetary constraints which accompany most impact assessments. Both the population and habitat approaches meet the criteria with the following basic differences:

(1) Population approaches result in analyses with actual dimensions (e.g., number of animals per unit area).

(2) Habitat approaches may be somewhat easier to implement when considering typical time and monetary constraints.

What is needed in impact assessment is a unifying concept which integrates features common to both the concepts of habitat with its relative ease of implementation and population with its explicit units of measure, or "a land parameter measured in animal units" (Giles 1978:194).

Understanding the relationships between habitat and animals requires that both the supply of habitat resources available and the life requirements of the species be known (Moen 1973). The supply of resources available to a particular animal can be determined from various characteristics of the habitat after the animal's requirements are known. For the better studied species these basic requirements, e.g., food, water, cover, and others, are reasonably well known. The unifying concept between habitat quality (i.e., the ability of a habitat to supply life requirements) and numbers of animals a habitat can support is carrying capacity.

4. Carrying Capacity and Habitat as a Basis for Impact Assessments

The concept of carrying capacity integrates the habitat and population themes in a time dimension and, in doing so, provides a potential basis for impact assessments. The purposes of this chapter are to define and discuss the estimation of carrying capcity, and then evaluate the utility of incorporating the concepts presented in this document into a practical method for assessing the impacts of man's actions on fish and wildlife resources.

4.1 Definition of carrying capacity. Strictly speaking, carrying capacity is a population concept with the underlying theme of numbers of animals supported by some unit of area. In population ecology terms, it is "the density of organisms (i.e., the number per unit area) at which the net reproductive rate (R_o) equals unity and the intrinsic rate of increase (r) is zero" (Pianka 1974:82). Pianka goes on to explain that carrying capacity is "an extremely complicated and confounded quantity, for it necessarily includes both renewable and nonrenewable resources, as well as limiting effects of predators and competitors, all of which are variables themselves." Carrying capacity is the "K" in various versions of the Verhulst-Pearl logistic population-growth equation. Defined in this context, carrying capacity is the population density at an upper asymptotic level of population growth. After a population reaches this level it may fluctuate around K due to chance events. The asymptotic density is maintained by density-dependent environmental factors.

Wildlife resource managers often are more liberal in their perceptions of carrying capacity than are population ecologists and may use the term in a variety of contexts (Edwards and Fowle 1955). When confusion occurs, it can be traced to a lack of user definition and not to the integrating role of this useful concept. Giles (1978) has recently attempted to alleviate confusion by suggesting that carrying capacity be defined for a population with a user-specified quality of biomass (e.g., specified sex and age ratios). With this approach, carrying capacity is the quantity of the specified population for which a particular area will supply all energetic and physiological requirements over a long, but defined, period of time.

4.2 Estimation of carrying capacity. Carrying capacity (K in the Verhulst-Pearl logistic population growth equation) may be estimated empirically with regression techniques described by Watt (1968) and Poole (1974). These regression techniques require that population densities be recorded for various stages of population growth. The technique is based on observed population densities, thus it does not provide the ability to predict future changes in carrying capacity. For that latter reason, and others discussed in 101 ESM 3, population estimation is not a viable technique for impact assessment purposes.

Another technique for estimating carrying capacity is the traditional resource inventory. With this technique, carrying capacity is estimated

resources. Predicted short-term (e.g., seasonal or annual) fluctuations in populations may have little influence on a land use decision. Secondly, the degree to which a predicted impact is considered significant is partially a function of socioeconomic preferences for the species involved. When recommendations for land use decisions are based on habitat potential it is possible to maximize the number of future management options, recognizing possible future changes in socioeconomic preferences.

4.4 Limitations of the habitat approach. The habitat approach, like any approach used for impact assessments, has limitations which define the limits of application and identify potential problem areas where good professional judgement is required. Performing impact assessments with a habitat approach, as described herein, basically limits application of the methodology to those situations in which measurable and predictable habitat changes are an important variable. Many impact studies (e.g., harvest management and predator control) cannot be adequately performed solely with a habitat approach but require other analytical capabilities.

The habitat approach presents a relatively static view of the ecosystem and forces a long-term "averaging" type of analysis. Although this is described as a positive attribute in earlier sections of this document, there is no assurance that wildlife populations will exist at the potential levels predicted by habitat analyses. A habitat approach may not include all of the many environmental or behavioral variables that often limit populations below the habitat potential. Moreover, socioeconomic or political constraints imposed by man may prevent the actual growth of certain species populations to their potential levels.

based on how well the habitat will meet the known physiological and behavioral needs of a species. Ecologists working with ungulates have historically based carrying capacity estimates on caloric and nutritional values of foods provided by the habitat. Examples of the data and calculations required are described by Moen (1973) and Mautz (1978). Others, including avian ecologists, have considered structural aspects of the habitat as important determinants of carrying capacity (Elton and Miller 1953). Carrying capacity estimates based on the resource inventory approach will nearly always be estimates of "potential," because the limiting effects of other species (competitors and predators) are difficult to explicitly include in the calculations.

4.3 Application of habitat concepts to impact assessments. Structural and physical features of habitat are measurable and because vegetational succession is predictable to a certain extent, future habitat values can be projected with some confidence. However, numbers of individuals fluctuate naturally over time and often independently of structural and physical features of available habitat. These fluctuations can be difficult to measure or predict and are often caused by epizootic diseases, excessive departures from normal weather patterns, or other stochastic events not directly related to habitat. More common however, are the effects of predation and competition on numbers of individuals utilizing a particular habitat (Wagner 1969; Partridge 1978). For example, predator-prey studies by Rogers et al. (1980) indicated that, in similar habitat, white-tailed deer densities were higher in the buffer zones between wolf pack territories than in the center of individual territories.

In regard to competition, avian ecologists are making rapid advances in deciphering the influence of competition on animal numbers. For example, a recent study (Williams and Batzli 1979a,b) indicated that the presence or absence of one particular species within a guild of bark foraging birds affected whether or not other guild members would use a particular habitat segment, how they would use it, and in what numbers. The implications of these studies and others are directly applicable to the objectives of impact assessment. Numbers of species and numbers of individuals often may change for unpredictable reasons, but habitat potential remains unchanged. Because of its relative stability, it is this habitat potential which should be documented by the wildlife manager interested in ecologically valid impact assessment.

Two factors support impact assessments based on habitat potential. First, the time scale for predictions can come close to matching the time span over which impacts will occur. For many impact studies performed by the USFWS involving long-term modifications of land use, the most useful information for decisionmaking is the long-term trend in fish and wildlife

5. A Habitat-Based Impact Assessment Technique

The USFWS (1980) has developed a procedure for documenting predicted impacts to fish and wildlife from proposed land and water resource development projects. The procedure is based on the concepts of habitat potential discussed in 101 ESM 4. The purpose of this concluding chapter is to briefly discuss the procedure and identify its strengths and limitations when used in the impact assessment process.

5.1 The Habitat Evaluation Procedures. The Habitat Evaluation Procedures (HEP) have been developed (USFWS 1980) in response to the need to document the nonmonetary value of fish and wildlife resources. HEP evolved from an assessment method developed in Missouri (Daniels and Lamaire 1974) and is based on the fundamental assumption that habitat quality and quantity can be numerically described. Numerical description permits options and alternatives to be compared when numerical changes are the essence of impact assessment.

HEP is a species-habitat approach to impact assessment, and habitat quality for selected evaluation species is documented with an index, the Habitat Suitability Index (HSI). This value is derived from an evaluation of the ability of key habitat components to supply the life requisites of selected species of fish and wildlife. Evaluation involves using the same key habitat components to compare existing habitat conditions and optimum habitat conditions for the species of interest. Optimum conditions are those associated with the highest potential densities of the species within a defined area. The HSI value obtained from this comparison thus becomes an index to carrying capacity for that species.

The index ranges from 0.0 to 1.0, and for operational purposes in HEP, each increment of change must be identical to any other. For example, a change in HSI from 0.1 to 0.2 must represent the same magnitude of change as a change from 0.2 to 0.3, and so forth. Therefore, HSI must be linearly related to carrying capacity. This is an operational restriction imposed by the use of HSI in HEP. However, it is a restriction easily complied with; if the relationship between HSI and carrying capacity is unknown, it is assumed to be linear. If the relationship is nonlinear, it is converted to a linear function.

HEP attempts to incorporate concepts from both the population and habitat theories by evaluating habitat quality for specific species. Prior to the 1980 edition of HEP, this was done subjectively based on the professional judgement of a team of biologists. The habitat quality values were multiplied by area and aggregated to obtain a "habitat" score. In the 1980 edition of HEP, HSI values are obtained for

individual species through use of documented habitat suitability models employing measurable key habitat variables (e.g., percent canopy closure). The HSI values are multiplied by area of available habitat to obtain Habitat Units (HU's) for individual species. These values are used in the HEP system for comparative purposes. No aggregation of species' HSI (or HU's) occurs.

Many potential users tend to consider the HSI value as synonymous with the entire HEP system. This is not the case. HEP can be compared to a bookkeeping ledger; both passively display, and thereby document, values obtained from other sources. HEP is a data management system; it is the data it manages, i.e., the index of quality and the quantity of available habitat, which are of interest in impact assessment.

5.2 Attributes and limitations of the Habitat Evaluation Procedures. As with other approaches, HEP differs in its ability to meet the previously identified evaluation criteria (101 ESM 3.2) for an impact assessment methodology:

(1) Various forms are used in HEP to display and document HSI, area, and HU's for each evaluation species. Comparisons can be made either between two areas at one point in time, or for one area for several points in time, for any proposed action. However, the ability to document data and ultimately compare alternatives is not unique to the HEP system.

(2) The differences in quality (HSI) and quantity (area) between existing habitat conditions (baseline) and various projected future sets of conditions document project-related impacts to selected evaluation species. HEP currently does not provide guidance for performing future projections. Therefore, projected impacts are no better than the user's ability to predict future conditions.

(3) HEP can be applied at any level of assessment. However, data requirements and costs increase as more species are considered and their respective habitat models become more complex. HSI models not only provide an index value of quality, but also document which habitat variables were considered and their respective values. The level of detail for such "models" must fit the user's objectives for impact assessment.

(4) The identification of differing types and magnitudes of impacts is dependent on the validity and sensitivity of the HSI models used to generate data for HEP. As with other approaches, the results of an impact assessment employing HEP are no better than the reliability of resource data used.

(5) HU's serve not only as the principal units of comparison in HEP, but also as a standard vehicle of communication, integrating both quality and quantity of habitat. Changes in HU's represent potential impacts from proposed actions. Such changes are annualized in order to be comparable with the action agencies' benefit/cost analyses. Applications of annualized HU's include impact assessments, compensation studies, and human use analyses. In such analyses, one HU lost for a species must be directly comparable to one HU gained for that species. The latter association explains the requirement for a linear relationship between HSI and carrying capacity.

(6) HEP is a species-habitat-based assessment methodology. It is applicable only for the species evaluated and does not directly relate that species with other ecosystem components. HEP conceptually addresses only the issues of species populations and habitat, among the four indicators of public interest identified in 101 ESM 2.3. However, the degree to which these indicators are addressed by HEP is dictated by the HSI models. Through improved HSI models, it may be possible to more completely treat the remaining issues of biological integrity and environmental values.

In summary, the HU data developed are the essence of the HEP methodology. The identified changes in habitat quality and quantity provide the basis for biologists to compare alternatives for the evaluation species selected. HEP is a convenient means of documenting and displaying, in standard units, the predicted effects of proposed actions. It is a tool available to resource managers who must make knowledgeable decisions. For further information, the reader should consult the "Habitat Evaluation Procedures" (102 ESM) and "Standards for the Development of Habitat Suitability Index Models for Use with the Habitat Evaluation Procedures" (103 ESM).

6. References Cited

Asherin, D. A., H. L. Short, and J. E. Roelle. 1979. Regional evaluation of wildlife habitat quality using rapid assessment methodologies. Trans. N. Am. Wildl. Nat. Resour. Conf. 44:404-424.

Balda, R. P. 1975. Vegetation structure and breeding bird diversity. pp. 59-80 In D. R. Smith (Tech. Coord.). Proceedings of the symposium on management of forest and range habitats for nongame birds. U.S.D.A. For. Serv. Gen. Tech. Rep. WO-1. Tuscson, Arizona. 343 pp.

Bean, M. J. 1977. The evolution of national wildlife law. Council on Environmental Quality. Washington, D.C. 485 pp.

Bean, M. J. 1978. Federal wildlife law. pp. 279-289 In H. P. Brokaw (Ed.). Wildlife and America. Council on Environmental Quality. Washington, D.C. 532 pp.

Black, H., Jr., and J. W. Thomas. 1978. Forest and range wildlife habitat management: ecological principles and management systems. pp. 47-55 In R. M. DeGraaf (Tech. Coord.). Proceedings of the workshop on nongame bird habitat management in the coniferous forests of the western United States. U.S.D.A. For. Serv. Gen. Tech. Rep. PNW-64. Portland, Oregon. 100 pp.

Congressional Research Service. The Library of Congress. 1977. A compilation of Federal laws relating to conservation and development of our Nation's fish and wildlife resources, environmental quality, and oceanography. Serial No. 95-B. Printed for the Committee on Merchant Marine and Fisheries. U.S. House of Representatives. Washington, D.C. 933 pp.

Coulombe, H. N. 1977. Summary remarks. pp. 593-604 In A. Marmelstein (General Chairman). Classification, inventory, and analysis of fish and wildlife habitat: the proceedings of a National symposium. FWS/OBS-78/76. Washington, D.C. 604 pp.

Daniels, C., and R. Lamaire. 1974. Evaluating effects of water resource developments on wildlife habitat. Wildl. Soc. Bull. 2(3):114-118.

Edwards, R. Y., and C. D. Fowle. 1955. The concept of carrying capacity. Trans. N. Am. Wildl. Conf. 20:589-602.

Elton, C. S., and R. S. Miller. 1953. The ecological survey of animal communities: with a practical system of classifying habitats by structural characters. J. Ecology 42:460-496.

6. References Cited

Giles, R. H., Jr. 1974. Forest-wildlife components of environmental impact statements. pp. 120-126 In J. P. Slusher and T. M. Hinckly (Eds.). Timber-wildlife management symposium. Missouri Academy of Science Occasional Paper 3. Columbia, Missouri. 131 pp.

Giles, R. H., Jr. 1978. Wildlife management. W. H. Freeman and Company. San Francisco, California. 416 pp.

Hurlbert, S. H. 1971. The non-concept of species diversity: a critique and alternative parameters. Ecology 52(4):577-586.

Inhaber, H. 1976. Environmental indices. John Wiley and Sons. New York, New York. 178 pp.

International Council of Scientific Unions. 1975. Environmental impact assessment: principles and procedures. SCOPE Workshop on Impact Studies in the Environments (WISE). United Nations Environmental Program (UNEP), Environmental Canada and UNESCO SCOPE Report 5, Toronto, Canada.

Johnson, P. L. (Ed.). 1977. An ecosystem paradigm for ecology. Oak Ridge Associated Universities, Oak Ridge, Tennessee. ORAU-129. 20 pp.

Kormondy, E. J. 1969. Concepts of ecology. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 209 pp.

Krebs, C. J. 1972. Ecology: the experimental analysis of distribution and abundance. Harper and Row Publishers, New York, New York. 694 pp.

Mautz, W. W. 1978. Nutrition and carrying capacity. pp. 321-348 In J. L. Schmidt and D. L. Gilbert (Eds.). Big game of North America. The Wildlife Management Institute and Stackpole Books, Washington, D.C. and Harrisburg, Pennsylvania. 494 pp.

McNaughton, S. J., and L. L. Wolf. 1973. General ecology. Holt, Rinehart and Winston, Inc. New York, New York. 710 pp.

Moen, A. N. 1973. Wildlife ecology. W. H. Freeman and Company. San Francisco, California. 458 pp.

Odum, E. P. 1971. Fundamentals of ecology. W. B. Saunders Company. Philadelphia, Pennsylvania. 574 pp.

Odum, E. P. 1977. The emergence of ecology as a new integrative discipline. Science 195(4284):1289-1293.

Odum, H. T. 1957. Trophic structure and productivity of Silver Springs, Florida. Ecol. Monogr. 27:55-112.

6. References Cited

Overton, W. S., and D. E. Davis. 1969. Estimating the numbers of animals in wildlife populations. pp. 403-455 In R. H. Giles, Jr. (Ed.). Wildlife management techniques. The Wildlife Society, Washington, D.C. 623 pp.

Partridge, L. 1978. Habitat selection. pp. 351-376 In J. R. Krebs and N. B. Davies (Eds.). Behavioral ecology: an evolutionary approach. Sinauer Associates, Inc. Sunderland, Massachusetts. 494 pp.

Pianka, E. R. 1974. Evolutionary ecology. Harper and Row Publishers. New York, New York. 356 pp.

Poole, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill Book Company. New York, New York. 532 pp.

Ricklefs, R. E. 1973. Ecology. Chiron Press. Newton, Massachusetts. 861 pp.

Rogers, L. L., L. D. Mech, D. K. Dawson, J. M. Peek, and M. Korb. 1980. Deer distribution in relation to wolf pack territory edges. J. Wildl. Manage. 44(1):253-258.

Smith, R. L. 1974. Ecology and field biology. Harper and Row, Publishers. New York, New York. 850 pp.

Thomas, J. W., C. Maser, and J. E. Rodiek. 1978. Edges--their interspersion, resulting diversity and its management. pp. 91-100 In R. M. DeGraaf (Tech. Coord.). Proceedings of the workshop on nongame bird habitat management in the coniferous forests of the western United States. U.S.D.A. For. Serv. Gen. Tech. Rep. PNW-64. Portland, Oregon. 100 pp.

Trefethen, J. B. 1975. An american crusade for wildlife. Winchester Press and the Boone and Crockett Club. New York, New York. 409 pp.

Udall, S. L. 1963. The quiet crisis. Holt, Rinehart, and Winston. New York, New York. 266 pp.

U.S. Fish and Wildlife Service. 1976. Habitat evaluation procedures. Division of Ecological Services. Washington, D.C. vi + 30 pp.

U.S. Fish and Wildlife Service. 1980. Ecological Services Manual (101-104 ESM), Division of Ecological Services, Washington, D.C. Unnumbered.

Wagner, F. H. 1969. Ecosystem concepts in fish and game management. pp. 259-307 In G. M. Van Dyne (Ed.). The ecosystem concept in natural resource management. Academic Press. New York, New York. 383 pp.

6. References Cited

Watt, K. E. F. 1968. Ecology and resource management. McGraw-Hill Book Company. New York, New York. 450 pp.

Wiens, J. A. 1978. Nongame bird communities in northwestern coniferous forests. pp. 19-31 In R. M. DeGraaf (Tech. Coord.). Proceedings of the workshop on nongame bird habitat management in the coniferous forests of the western United States. U.S.D.A. For. Serv. Gen. Tech. Rep. PNW-64. Portland, Oregon. 100 pp.

Williams, J. B., and G. O. Batzli. 1979a. Competition among bark-foraging birds in central Illinois: experimental evidence. Condor 81:122-132.

Williams, J. B., and G. O. Batzli. 1979b. Interference competition and niche shifts in the bark-foraging guild in central Illinois. Wilson Bull. 91:400-411.

APPENDIX B

GUILDING APPROACH TO SPECIES SELECTION

GUILDING APPROACH TO SPECIES SELECTION *

When only a limited number of species may be evaluated, a guilding approach may be useful in providing a biological basis for species selection. A guild is defined as a group of species that utilize a common resource in the environment. Guilds can be defined in any level of detail, i.e., generalized with a large number of species or defined to the degree that each guild defines the niche of one species, or some level of detail in between. The advantages and disadvantages of using the guilding approach are summarized in Figure 1.3.

Advantages of Guilding

1. Allows an evaluation team to address the species that will be sensitive to the proposed land use; i.e., it provides a basis for a better assessment of project impacts.
2. Aggregation of species into guilds and the subsequent selection of representative species may allow inferences to be drawn about project impacts to other guild members, which may permit a more holistic evaluation of potential impacts with a manageable number of species.
3. Provides an ecological basis for impact assessment.
4. Provides documentation of the reasons behind the final selection of species to be evaluated.

Disadvantages of Guilding

1. The guilding process itself may be too time-consuming for a specific project.
2. Species selected to represent a guild may be unfamiliar to the general public.
3. Guilding may mask differences between species (depending on the level of detail used to define guilds).

Figure 1.3. Advantages and disadvantages of using the guilding process for species selection.

* U.S. Fish and Wildlife Service, 1985.

A prescreening process that considers expected impacts on cover types and guilds will help focus an evaluation on those species that are expected to be sensitive to project impacts. The first step in the prescreening process is to consider those cover types that will be impacted by a proposed action. For example, if project impacts will affect only wetlands and lowland agricultural lands, then species that use only the upland cover types need not be considered in a HEP analysis. Once potentially impacted cover types have been identified, then the guild concept can carry the prescreening process one step further. Although some project impacts may completely eliminate all guilds within a cover type (e.g., inundation of a forest), other impacts may not be uniformly distributed within a cover type. If impacts are concentrated on certain guilds (e.g., grazing impacts are concentrated on the terrestrial surface rather than in the tree canopy), then the HEP analysis should focus on those species that utilize those resources that are most likely to be impacted by a proposed action.

Five steps are involved in using the guilding process for species selection. These are:

(1) determine guild categories;
(2) identify guild descriptors;
(3) develop the guild matrices;
(4) enter candidate species into the appropriate cells of the guild matrices; and
(5) select evaluation species.

Step 1. Determine guild categories.

Terrestrial guild categories can be based on feeding and reproductive considerations, and the locations within the habitat where these activities occur. Aquatic guild categories may be based on reproductive and feeding considerations, tolerance to temperature changes or turbidity, preferred cover, or other categories.

Step 2. Identify guild descriptors.

Guild descriptors define the various levels of detail possible within each guild category (e.g., a feeding guild may inlude locational descriptors such as bottom feeders or water column feeders, or trophic level descriptors such as herbivore, planktivore, or carnivore). Guild descriptors should be identified to a level of detail appropriate to project impacts. For example, if the canopy of a forest will not be impacted by a proposed land use (e.g., grazing), then the use of tree canopy as a locational descriptor is unnecessary. On the other hand, if a proposed management action includes periodic burning of the ground cover, then this stratum should be included as one of the locational descriptors.

Step 3. Develop the guild matrix.

Guild descriptors are used to construct a matrix for each cover type likely to be affected by the proposed action. The matrix consists of cells which represent the potentially sensitive guilds within each cover type.

Step 4. Enter candidate species into the appropriate cells of the guild matrix.

Potentially impacted species should be entered into the appropriate matrix cells. Some cells may contain several species. A cell may not contain any species because no potentially impacted species logically occurs in that guild. An individual species may be placed in more than one cell (e.g., the white-tailed deer may feed in both the shrub stratum and the terrestrial surface stratum).

Ideally, all species that are potentially sensitive to project impacts should be considered. Practically, however, this may be too time-consuming if a large number of species are involved. At a minimum, enough species should be considered such that at least one species occurs in each guild

cell, if at all possible. The judgement of the HEP team is required in limiting the number of species considered beyond the minimum.

Step 5. Select evaluation species from the guild matrices.

The final step in this approach is the actual selection of evaluation species. Ideally, one species should be selected from each guild. Where several species occur within a guild, selection criteria may be established for prioritizing species within the guild. Selection criteria should be developed by the evaluation team. Examples of selection criteria are presented in Figure 1.4. The species perceived to be most important in light of the selected criteria should be selected to represent each guild.

Within-Guild Selection Criteria	Rating
Anticipated sensitivity to potential project impacts:	
• Highly sensitive to proposed water and land use changes	4-5
• Moderately sensitive to proposed changes	2-3
• Insensitive to proposed changes	1
2. Limitation of geographic range:	
• Extremely limited range largely confined to the project area	5
• Moderately limited range but also found outside the project area	2-4
• Broad geographic range beyond the project area	1
3. Availability of habitat data:	
• Species-habitat relationships well documented with data	4-5
• Species-habitat relationships partially documented	2-3
• Species-habitat relationships not well documented	1

Figure 1.4. Examples of selection criteria that may be used to rank species within guilds.

INFERENCES FROM EVALUATION SPECIES TO OTHER SPECIES

An impact assessment based on HEP is directly applicable only to the species selected for evaluation. One of the advantages to guilding, however, is that it provides the opportunity to use predicted impacts on selected species to predict impacts on other species. The extent to which such inferences may be made depends on both the perceived impacts to the evaluation species and the level of detail used to define the guild(s).

Inferences may be made from the predicted impacts on an evaluated species to other species if they all share a common resource that is being impacted. For example, an evaluation may indicate a loss of habitat units for a raptor as the result of a predicted reduction in the prey base. Such an impact can be safely extrapolated to other species that also depend upon the same prey base. On the other hand, a reduction in habitat units for the white-tailed deer may be due to a loss of winter cover. Inferences cannot be made that other species in the same feeding guild (e.g., eastern cottontails in grasslands) will be similarly affected, since the predicted impacts affect deer cover rather than food.

If predicted impacts are due to changes in resources shared by several species, then possible extrapolation from impacts on an evaluated species to non-evaluated species will depend on the level of detail used to define common resources in the guild(s). If the guild descriptors define broad guilds (e.g., all carnivores), then inferences may be made but with low confidence. The greater the level of detail used in describing guilds, the greater will be the level of confidence with which inferences may be made. For example, if carnivores are separated into those that feed on vertebrates and those that feed on invertebrates, then inferences from an evaluated species to other species within the guild can be made with a greater degree of confidence than would be possible if the guild was described by the general category of carnivore.

REGIONAL GUILDS

It may be desirable to construct guilds for all species within a region and develop a tentative list of candidate evaluation species. Although the initial investment of time may be considerable, the list could be used for species selection on numerous projects. In regions where numerous projects are anticipated, the initial guilding of all species in the region may be an efficient use of both time and money. Since study objectives will vary between projects, it may be desirable to construct several lists with different levels of guild descriptor detail. There would then remain only the task of each evaluation team to develop project specific selection criteria with which to make the final selection of evaluation species.